JOURNAL
OF THE
FRANKLIN INSTITUTE
OF THE
State of Pennsylvania,
AND
MECHANICS' REGISTER.
DEVOTED TO
Mechanical and Physical Science,
CIVIL ENGINEERING, THE ARTS AND MANUFACTURES,
AND THE RECORDING OF
AMERICAN AND OTHER PATENTED INVENTIONS.

AUGUST, 1837.

Practical and Theoretical Mechanics.

Report of the Committee of the Franklin Institute of the State of Pennsylvania on the Explosions of Steam Boilers, of Experiments made at the request of the Treasury Department of the United States. PART II. *Containing the report of the sub-committee to whom was referred the examination of the strength of the materials employed in the construction of Steam Boilers.*

[CONTINUED FROM PAGE 31.]

Second method of observing elasticities.]

Another method of approximately determining the elasticity of iron as indicated when subjected to different strains, was to measure directly on the specimen under trial the distance between two points, taken as remote from each other as possible, both when under strain and when that strain was removed.

Thus bar No. 49 having been permanently elongated $\frac{3}{10}$ of an inch, in $20\frac{3}{10}$, under a weight of 273 pounds in the scale, gave a recoil of .05 of an inch. Afterwards with a weight of 301 lbs., and when a permanent elongation of .58 inch, in the same original length had taken place, the recoil amounted to $\frac{1}{348}$ of the total length. After that trial 15 pounds in addition were required to break the bar.

On bar 226 the first permanent elongation was found under a weight of 245 pounds. Under a weight of 280 pounds the elongation in 24 inches was .86 inch, and when relieved it was .82, giving a recoil of .04 in 24 inches,$=\frac{1}{600}$. After this last trial 35 pounds additional weight were required to produce the fracture.

On bar 228, we find that the first elongation was taken under a weight of 232 pounds. With 238 pounds it had become .146 inch on a length of 24; but when relieved the recoil was .046 inch, equal to $\frac{1}{523}$ of the length. Twenty-eight pounds were afterwards required to be added to break the bar.

On bar 230 the elongation took place under 196 pounds. With 317 pounds the recoil on a part originally 24 inches long was .05 inch, equal to $\frac{1}{480}$ of the whole original length, and 13 pounds more were required to produce the fracture.

Experiments and remarks on this subject will be found in Tables XXXVII., XL., LV., LIX., &c.

TABLE XCII.—*Synopsis of the elasticity of 56 different bars of iron of given lengths, under certain weights, and also the breaking weights of the same bars as found immediately subsequent to the*

No. of the bar and direction of the slit.	Length under trial.	Weight in the scale.	Elasticity observ. corrected for the machin.
2.	23.55	280	15′
L'gth.		336	16
		392	19
		448	25
		474	21.5
		479	Broke.
4. L.	13.2	224	35
		336	38
		448	16
		460	Broke.
8.	21.2	280	20
Cross.		336	22
		392	15
		430	15
		443	Broke.
17. Cr.	23.9	259	23
		280	22
		294	14
		326	17.5
		336	21
		350	24
		364	31.5
		371	27
		374	Broke.
18. Cr.	Unc.	392	32
		403	37.5
		412	39
		415	26
		415	Broke.
21. L.	17.4	280	25
		321	26.5
		336	28
		356	Broke.
23. L.	24.3	280	21
		364	31
		393	Broke.
23. L.	21.1	280	29
		364	22
		413	57
		426	Broke.
25. L.	24.1	224	39
		361	28.5
		370	Broke.
27. L.	24.2	224	35
		336	38
		392	53
		403	Broke.
32. Cr.	23.	112	10.5
		168	10
		224	12
		280	13.5
		336	16
		392	17
		410	Broke.
37. L.	22.	112	23
		162	43
		171	Broke.
39. C.	23.5	224	20′
		314	31
		317	Broke.
41. L.	23.35	224	45
		282	27.5
		292	Broke.
42. L.	23.8	224	27
		336	32
		399	28.5
		427	31
		443	Broke.
42. L.	22.45	399	28.5
		427	31
		452	Broke.
42. L.	18.8	399	28.5
		462	22
		462	Broke.
44. L.	23.7	224	25
		336	25
		448	23
		476	36
		496	34
		503	Broke.
46. L.	24.4	224	29
		280	29
		297	28.5
		314	Broke.
48. L.	24.5	224	16
		336	18
		425	21.5
		444	30
		464	27
		478	31
		487	28
		503	Broke.
51. C.	24.	224	53
		336	53
		448	27
		464	32
		472	Broke.
53. C.	24.	224	37
		336	36
		448	21
		464	22
		478	Broke.
53.	21.	494	25
		500	Broke.
56. C.	23.7	224	07
		336	07
		448	21
		471	Broke.
56. C.	20.3	448	25
		495	Broke.
58. C.	23.7	224	49
		336	54
		392	50
		448	44
58. C.	22.35	448	26′
		479	Broke.
58. C.	20.7	479	57
		496	Broke.
59. L.	23.5	112	12.5
		168	20
		224	27
		242	27
		258	Broke.
61. L.	23.6	224	40
		280	42
		326	38
		332	36
		336	Broke.
68. L.	24.	224	32
		336	31
		392	28
		414	30
		441	32
		450	Broke.
68. L.	20.8	224	32
		448	20
		455	Broke.
70. L.	24.2	112	19.5
		224	16
		280	19
		336	23
		364	26
		377	Broke.
64. C.	24.2	112	38
		224	55
		280	51.5
		301	52.5
		329	46
		335	Broke.
65. C.	24.25	224	19
		280	18
		336	27
		369	Broke.
71. C.	24.1	224	20
		336	27
		357	Broke.
71. C.	23.1	336	28
		392	26
		414	Broke.
73. C.	23.95	112	5.5
		224	11
		280	18
		308	19.5
		322	33
		336	24
		342	Broke.
85. L.	24.5	112	11.5
		224	15
		336	33
		392	38

[TABLE XCII. continued] *time of taking the elasticity. The direction of the slitting is indicated by the letters in the left hand column.*

No. of the bar and direction of the slit.	Length under trial.	Weight in the scale.	Elastic. observed correct. for the machine.	No. of the bar and direction of the slit.	Length under trial.	Weight in the scale.	Elastic. observed correct. for the machine.	No. of the bar and direction of the slit.	Length under trial.	Weight in the scale.	Elastic. observed correct. for the machine.
		420	36′	101. L.	25.1	224	35′			420	51′
		448	24			336	41			438	49
		462	Broke.			403	Broke.			448	45
85. L.	22.1	224	15	103. C.	23.8	224	38			462	46.5
		336	23			280	34			468	Broke.
		392	24			308	43.5	174. D.	30.2	219	45.5
		462	28			321	Broke.			227	50.5
		481	Broke.	103. C.	9.6	168	7			235	Broke.
87. L.	24.5	224	21			361	Broke.	174. D.	27.7	231	65
		336	16	105. L.	24.2	224	63			235	Broke.
		392	25			294	64	174. D.	23.9	231	41
		441	25			320	63			245	44
		464	Broke.			322	Broke.			246	Broke.
75. L.	24.6	257	8	130. C.	16.6	56	8	174. D.	22.1	245	39
		262	Broke.			112	8.5			246	Broke.
75. L.	21.4	168	10			168	9	148. C.	unc.	212	29
		267	Broke.			224	11			336	33
78. L.	24.4	112	14.5			280	13.5			392	42
		224	17.5			336	12			448	45
		280	21			436	16			463	Broke.
		280	Broke.			466	12	148. C.	20.6	463	37
78. L.	Unc.	224	54			485	16			476	Broke.
		293	Broke.			506	24	151. C.	30.5	224	30
83. C.	24.	224	34			529	Broke.			336	33
		273	Broke.	137. Diagonal.	4.	490	44			448	40
84. C.	23.8	168	50			498	Broke.			476	Broke.
		224	52	142. L.	30.4	112	8.5	151. C.	29.8	476	36
		275	54			224	14			489	Broke.
		289	Broke.			280	15	167. C.	30.4	224	38
84. C.	9.	224	33			336	27			266	36
		317	24			364	26.5			284	42
		319	Broke.			380	32			292	Broke.
84. C.	15.2	280	53			398	31.5	167. C.	19.33	306	29
		294	Broke.			415	Broke.			307	Broke.
91. C.	24.	112	50.5	143. L.	30.6	224	30	160. L.	30.2	224	82
		224	76			280	33			245	Broke.
		280	60			336	48	160. L.	22.25	252	64
		347	34			370	53			257	Broke.
		364	20			392	52	162. L.	30.2	168	60
		392	Broke.			435	44			224	65
94. L.	24.07	224	37			440	47			252	58
		280	45			440	Broke.			256	Broke.
		336	38	143. L.	29.3	464	41	162. L.	27.6	262	72
		392	36			478	Broke.			262	Broke.
		448	25	154. D.	30.4	224	30	181.		112	20.5
		483	25			336	30	Steel		224	30
		511	Broke.			392	38	bar.		336	28
95. C.	24.1	224	34			420	42			385	36.5
		336	26			427	Broke.			406	40.5
		382	Broke.	154. D.	23.08	392	21			415	39.5
99. C.	24.3	224	20			438	Broke.			422	36.5
		336	36	157. D.	30.35	224	27			429	37.5
		378	42			336	50			441	Broke.
		378	Broke.			392	50				

TABLE XCIII.

Comparative view exhibiting the areas of section at the points of fracture in 151 *experiments on* 67 *different specimens of iron, embracing*

No. of the comparison.	Number of the specimen referred to.	No. of experiments on the respective specimens.	Area, after fracture, of strips cut lengthwise, compared with their original area as unity.	Area of section of fracture of specimens cut transversely, their original area being 1.	Mean area of length strips in each kind of iron.	Mean area of cross strips in each kind of iron.
1	2	2	.887			
2	4	2	.829			
3	6	2		.904		
4	8	1		.895	.858	.899
5	9	1	.876			
6	11	2	.771			
7	21	2	.909			
8	23	3	.876			
9	13	2		.860		
10	15	1		.867		
11	18	1		.964	.858	.897
12	25	6	.824			
13	27	1	.936			
14	35	1	.909			
15	37	1	.949			
16	32	1		.840		
17	39	1		.934		
18	41	1		.927	.904	.900
19	42	3	.923			
20	43	1	.924			
21	44	2	.914			
22	56	2		.920		
23	58	4		.883	.920	.901
24	46	2	.790			
25	48	2	.761			
26	51	2		.838		
27	53	2		.865	.775	.851
28	59	1	.890			
29	61	1	.891			
30	64	1		.967		
31	65	1		.940	.890	.953
32	68	2	.833			
33	70	1	.858			

Number of the comparison.	Number of the specimen.	Number of experiments on the respective specimens.	Area after fracture of strips cut lengthwise, compared with their original area as unity.	Area after fracture of specimens cut transversely.	Area after fracture of specimens cut diagonally.
34	71	4		.781	
35	73	1		.830	
36	85	3	.889		
37	87	2	.800		
38	75	1	.869		
39	78	1	.840		
40	81	1		.978	
41	83	3		.901	
42	84	3		.859	
43	94	4	.760		
44	95	5		.872	
45	99	1		.947	
46	103	2		.810	
47	107	3		.816	
48	101	2	.849		
49	105	1	.895		
50	125	2	.502		
51	130	1		.766	
52	133	5		.587	
53	135	5			.512
54	137	3			.544
55	142	1	.941		
56	143	3	.780		
57	160	5	.772		
58	162	2	.735		
59	164	5	.457		
60	148	2		.885	
61	151	5		.847	
62	167	2		.729	
63	169	6		.835	
64	154	3			.877
65	157	1			.842
66	171	1			.412
67	174	4			.805

TABLE XCIII.

11 kinds of metal, distinguishing those specimens which were cut lengthwise from those which were cut crosswise and diagonally from the sheet.

Mean area of longitudinal specimens.	Mean area of transverse specimens.	Mean area of diagonal specimens.	REMARKS.
·845	.805		
.849	.912		From this table it appears that the areas of fracture in strips cut across the direction of the rolling, are greater than in those cut longitudinally. The difference in this respect on the 12 different kinds, averages 6 per cent. of the area of the fractures in the longitudinal strips,—a difference corresponding very nearly with the difference in *strength* of longitudinal and transverse strips as contained in Tables XCV. and XCVI.
.760	.872		
.872	.857		It also appears that of the 12 different sorts of iron compared, 8 exhibit a diminution of area in the *length* strips, greater than in those cut across the direction of the rolling, and 4 show a small balance in the opposite direction.
.502	.679	.523	The mean difference of the 8 sets first mentioned, is .861—.778=.083 of the original area, or .107 of .778, the remaining area in the case of the length strips. The mean of all the 67 comparisons in all directions exhibits the diminution of area from 1.000 to .835, or a "constriction" of .165=1–6 the original size, and of course a corresponden increase of length at the parts in the immediate vicinity of the fractures.
.737	.824	.859	

Diminution of area at the moment of fracture.

With a view to determine within certain limits the extensibility of iron when subjected to strain, and to compare the same in specimens cut across the sheet with that of longitudinal strips, a considerable number of measurements were taken at the sections of fracture after the experiment, and from these the above table of results is exhibited, indicating the mean result of the trials on each bar and the ratio of the remaining area to the original area taken as unity.

In taking these measurements some little uncertainty is to be admitted, owing to the fracture taking occasionally a diagonal direction, but as the two fragments afforded the means of obtaining corrections, the error from this cause cannot have, at most, exceeded a few thousandths of an inch.

By referring to the table of permanent elongations as taken on the whole bar, (Table XCIV.), it will be seen that the greatest extension observed on an entire bar, previous to the first fracture, was 3 inches in 24 or $\frac{1}{8}$ of the total length. This was on a bar reduced to a uniform size. But as no bar of iron, of any considerable length, is of uniform strength throughout, we are not to expect in any case an extension in length *of the whole bar* equal to the diminution of area at the point of fracture.

One remark worthy of particular attention, in connection with our subject, is, that at elevated temperatures, before the diminution of strength has begun to be felt, the diminution of area or *constriction* of iron is often much less, than when the trial is made on the cold metal. This is particularly exemplified in bar No. 164, in which two experiments at 577°, gave a tenacity 14 per cent. greater than five others, made at from 75° to 80°, while the constriction was less in the hot trials than in the cold, in the proportion of .338 to .447, or about *one-third*. In this and similar cases the fractures at high temperatures were observed to take place suddenly, and the surfaces of fracture to present appearances altogether different from those found in cases where the same bar was broken cold. This peculiarity consisted in a smooth section, directly across the breadth of the filed portion in which they took place, but uniformly inclined to the flat face of the bar, in an angle of about 45 degrees, and presenting therefore a bevel, like the cutting edge of a common mortising chisel.

In a few instances, particularly in experiments on bars as they came from the shears, the fracture was compound, the strengths at two neighboring sections being so exactly equal as to separate simultaneously, at the distance of half an inch or an inch from each other.

Bars 228 and 230, the former of which was cut crosswise, and the latter lengthwise of the sheet, and both broken up at ordinary temperatures, indicated a marked difference in the nature of the surfaces of fracture. The former presents, in nearly all instances, irregular and jagged surfaces inclining to compound fracture, or displays rough sections perpendicular both to the edges and faces of the bar. The latter is oblique and fibrous.

The amount of constriction in strips cut across the direction of rolling is, on an average, about 6 per cent. less than in those cut longitudinally.

A careful comparison of the breadths and thicknesses before and after fracture would show that the diminution in thickness follows a more rapid rate than that in breadth, whether the iron be hammered or rolled, and whether in the latter case, it be cut lengthwise or crosswise of the sheet.

The amount of constriction observed, viz: 16¼ per cent., is rather less

than that obtained by M. Martin,* who operated chiefly on rolled bars or bolts of considerable magnitude, and found on an average of 35 comparisons $18\frac{6}{10}$ per cent. of elongation.

The above table will show that the difference in different kinds of metal in respect to the diminution of *area* of fracture is very marked, sometimes exceeding 54 per cent. of the whole original area; while at others it scarcely exceeds 5 per cent.

The difference in the extensibility of iron in the longitudinal and the transverse directions of the sheet is liable to manifest itself in practice, when a portion of a boiler becomes locally so overheated as to bulge out in a particular spot. It will then be seen that an elongated protuberance is exhibited, having the greater axis in the direction across the sheet, and the less lying in the course of the rolling.

The piece taken from an old boiler which had been burst in consequence of the gradual overheating of a portion over the fire where sediment had collected, and which will be referred to in another part of this report, exemplifies the kind of action above described. The extent of the swelling in the direction of the length of the sheet was $10\frac{1}{2}$ inches, which, measuring over the summit of the bulge, had become $12\frac{1}{4}$ inches; or the increase of distance over the surface of the metal was .167 of the original extent. In the transverse direction of the rolling, the original length of the swollen part was $20\frac{1}{2}$ inches, and the line applied over the summit measured 23 inches, or the increase in this direction was .122 of the original length. Hence the extensions of this specimen of iron in the two directions are to each other as 167 to 122.

Some idea may be formed of the extent of constriction in *breadth*, both of iron and copper bars under various temperatures, by inspecting Plate II. m and m' are two portions of bar No. 164, Table XLVIII., which was prepared by filing notches on its sides. The portion m, of which the breadth before trial was .747 inch in the deepest part of the filed section and .132 inch thick, was broken at a temperature of 576°. Strength, 66336 pounds per square inch. The breadth after fracture was .674 inch, and the thickness .102. The surface clean, smooth and bevelled in an angle of about 45°. The diminution of area is consequently .098604—.068781= .029823 square inch. m' represents a portion broken in experiment 15 of the same table, at a temperature of 87.5°, giving a strength of 56503 pounds per square inch, and a section of fracture measuring .601 in breadth and .07 in thickness;—whereas the original breadth had been .731 and thickness .138; so that the constriction was here .100878—.042070=.058808 square inch,—almost exactly double as much as when broken at 576°. Experiment 17 on the same bar affords another illustration of the effect of a moderately elevated temperature in preventing constriction.

The original breadth of the bar in which these notches were filed was 1.117 inch. Hence the notches in m were each $\frac{1.117—.747}{2} = .185$ inch deep, and those in m' each about .193 inch, in both cases quite sufficient to preclude the supposition of any weakening effect of the shears, within the part left after filing.

n and n' are portions of the bar of iron, No. 224 C, an account of which is given in Table LXXII. The breadth before trial of this bar, which was reduced

* See Annales des Mines, 3d series, Vol. V. 1st part.

to uniform size by filing, is indicated by the dotted lines outside of the plain ones, while the inside dotted lines mark the breadths after fracture. Both portions were broken at low temperatures. *n'* in experiment 5 of that table, at a temperature of 80°, exhibited a strength of 62472 pounds per square inch, a breadth of section=.572 inch, and a thickness of .159, consequently giving an area of section after fracture of .090948 square inch, whereas the area before trial was .182945, and the constriction .091967, a trifle more than 50 per cent. of the original section. The fracture on the portion *n* was made at the 8th experiment of the same table when the temperature was 71°, and within one inch of the point broken in the trial just referred to. But previously to this fracture, the specimen had been submitted without access of air to a bright welding heat, so as perfectly to anneal the iron without oxidizing it. The strength was then found to be only 36052 pounds per square inch, reckoned on the original section at that part of the bar, the breadth being .457 inch, the thickness .118, and the area .053926; while the original breadth had been .757, original thickness, .24125, and area .182626, which had been reduced before the annealing to .150664. Hence the constriction after annealing was .182626—.053926=.128700, or 70.4 per cent. of the original cross section of the bar.

o and *o'* represent specimens of copper bar, No. 7 table XXII., to which we have already referred in speaking of the extensibility of that metal.

Forces producing permanent elongations of iron.

In connexion with the subjects of tenacity and elasticity, it has generally been deemed important to pay some attention to the relation between the forces which will break, and those which will elongate the specimens to a sensible degree, rendering them incapable of returning to their original dimensions. The committee have not been unmindful of this subject, and the following table will exhibit the most important of these observations, which have, during the course of our experiments, been made to bear directly on this point. An inspection will show that the first permanent elongation may take place under forces varying according to the character of the materials. Those kinds which possess the greatest extensibility begin in general earliest to manifest this property, in yielding *permanently* to low degrees of force. This remark is exemplified by a comparison between Nos. 226 and 219 A., the latter of which showed an extensibility before fracture of 2.5 inches in 24, or about $\frac{2}{19}$ of its whole length, and began to extend with $41\frac{2}{3}$ per cent. of the breaking weight, while the former was extended $\frac{1}{14}$ of its length, or $1\frac{1}{2}$ inch in 24, and required 76 per cent. of the breaking weight to cause the first elongation. The *extremes* lie between .416 and .872 of the ultimate strength; and the mean of 13 comparisons is .641, conforming nearly with the results obtained by former experimenters.

The eighth and ninth columns of the following table show the total elongation at the moment of fracture. This must necessarily be different in different bars, as well on account of the diversity in their constitution, as of the unequal degrees of *uniformity* in size and structure in different parts of the same bar.

TABLE XCIV.

Comparative table exhibiting the amount and relations of the weights required to produce the first permanent elongation in different bars of iron, and the weights required for the first fracture of each bar, also the amount of permanent elongation of the specimen, and the ratio which that elongation bears to the entire length before trial.

No. of the Comparison.	Mark of the bar affording the comparison.	Original length of the part measured.	Strength in lbs. per square inch, exhibited by the first fracture.	No. of pounds in the scale at the first frac.	Wt. in the scale at 1st permanent elongation.	Ratio of the *elongating* to the *breaking weight.*	Elongation in inches, at the time of fracture.	Pt. by which the original l'gth was increased.	REMARKS.
		X	X						
1	49	20.3	57565	316	245	.775	1.42	$\frac{1}{14}$	When strained with 273 lbs. and then relieved, the recoil of the part within the marks originally 20.3 in. apart, was .05 of an inch; with 301 lbs. in the scale it was .06, and with 306 lbs. it was .04. The mean of these 3 trials of the recoil, shows that it amounted to $\frac{1}{406}$ of the original length.
2	149	24.	52778	334	224	.670			
3	150	24.	59397	346	196	.566	1.5	$\frac{1}{16}$	
4	191	15.	47991	326	210	.644	1.42	$\frac{1}{11}$	
5	219 A.	24.	52257	267	112	.416	2.5	$\frac{1}{9.6}$	
6	220 B.	24.	58642	336	184	.547	3.+	$\frac{1}{8}$	Under 289 lbs. the 24 inches had become 27, and the bar had extended very uniformly.
7	223 A.	24.	43766	269	168	.622	1.+	$\frac{1}{24}$	
8	223 B.	22.	41555	262			2.55	$\frac{1}{8.6}$	The first permanent elongation of this bar was not observed, but under a weight of 245 lbs. in the scale the elongation was .7 inch.
9	226	24.	49053	315	240	.761	1.5	$\frac{1}{16}$	
10	228	24.	40643	266	232	.872			Under a weight of 238 lbs. in the scale, the elongation in 24 inches was .146 inch; but when relieved the recoil was .046, showing the permanent elongation to be .1 inch, and the ratio of the recoil to the total length $\frac{1}{231}$.
11	229	12.	46473	301	210	.697			
12	230	26.	49368	330	196	.594	2.36	$\frac{1}{11}$	
13	231	22.	68513	465	308	.662			
14	232	24.	57039	376	196	.508			
			Mean of 13			.641			
			Maximum			.872			
			Minimum			.416			

It is not only desirable to mark the force which will produce the first permanent elongation of iron, but also to ascertain the successive elongations under different weights, since in the case of the steam-boiler it may be necessary to know what degrees of distortion in its form would result from the various forces which might be applied to it. It is true that in producing these successive elongations *time* may enter as an element into the result; but the experiments of the committee on this subject, were generally conducted with such deliberation as to preclude the supposition that a longer continuance would have materially altered the effects observed. In determining this question, recourse was had to two methods; first, that of direct measurement of the lengths after certain elongating forces had been applied, and secondly, that of gauging the cross sections at numerous equi-distant points along the bar, the results of which showed the irregularity of extension as well as its actual amount in the vicinity of each section so gauged.

Table XLVIII. affords an example of the latter kind of trials, in which the bar was gauged each time, after eight different experiments.

Tables XXXVIII., XXXIX., XLII., LXXXII., LXXXIII., LXXXIV. and LXXXVII., will also be found to contain accounts of similar measurements of cross sections.

Experiments and observations on the progressive extensions *in length* of bars of iron, will be found in Tables XXXVII., XXXVIII., LXV., LXXXII. and LXXXIV.

Strength of iron in different directions of the rolled sheet.

In obtaining specimens for these experiments, care was generally taken to have them cut in different directions of the rolling, longitudinally and transversely, and in some cases *diagonally*, to that direction. The tables will be found to indicate the direction of slitting in each case, and the comparison contained in Tables XCV. and XCVI. is given to show what information the inquiry has elicited.

The comparison is made principally on the *minimum* strength of each bar, being that which can alone be relied on in practice; for if the strength of the weakest point in a boiler be overcome, it is obviously unimportant to know that other parts had a greater strength. In one case, however, two bars, one cut across the direction of rolling and the other longitudinally, were, after being reduced to uniform size, broken up cold, with a view to this question. The result shewed that the length-strip was $7\frac{1}{10}$ per cent. stronger than the one cut crosswise, considering the tenacity of the latter equal to 100. Of the other sets, embracing about 40 strips cut in each direction, it appears that some kinds of boiler iron manifest much greater inequality in the two directions than others. It is in certain cases not much over one per cent., and in others exceeds twenty, and as a mean of the whole series it may be stated to amount to six per cent. of the strength of the cross-cut bars. The number of trials on those cut diagonally is not perhaps sufficiently great to warrant a general deduction, but so far as they go, they certainly indicate that the strength in this direction is less than in either of the others.

Had we compared the mean instead of the least strength of bars as given in the table, the result would not have differed materially in regard to the relative strength in the respective directions.

For this purpose the boiler-iron manufactured by Messrs. E. H. & P. Ellicott, which was tried in all three of the directions of the sheet, and by all the three modes of preparation of specimens, will be found to give the following results,—viz, 1. When tried at *original sections*, seven experiments on length-sheet specimens gave a mean strength of 55285 lbs. per square inch, the lowest being 44399, and the highest 59307. Fourteen experiments on cross-sheet specimens gave a mean of 53896 lbs., the lowest result being 50212, the highest 58839; and six experiments on strips cut diagonally from the sheet, exhibited a strength of 53850 lbs., of which the lowest was 51134, and the highest 58773.

2. When tried by filing notches on the edges of the strips to remove all weakening effect of the shears, the *length-sheet* bars gave, at fourteen fractures, a mean strength of 63946, varying between 56346 and 78000 lbs. per square inch. The cross-sheet specimens tried after this mode of preparation, exhibited, at three trials, a mean strength of 60236 lbs., varying between 55222 and 65143; and the *diagonal* strips, at four trials, gave a mean result of 53925, the greatest difference being between 51428 and 56632.

3. Of strips reduced to uniform size by filing, four comparable experiments on those cut lengthwise of the sheet, gave a mean strength of 63947, of which the highest was 67378 and the lowest 60594.

Cross-sheet specimens tried after the same preparation, exhibited, at thirty-three fractures, a mean of 50176, of which the highest was 65785 and the lowest 52778. No bar cut diagonally was reduced to uniform size.

From the foregoing statements it appears that by filing in notches and filing to uniformity, we obtained results 63946 and 63947 for the strength of strips cut lengthwise, differing from each other but a single pound to the square inch, and that by these two modes of preparation the cross-sheet specimens gave respectively 60236 and 60176, differing by only 60 lbs. to the square inch. This seems to prove that by both methods of preparing the specimens the accidental weakening effect of slitting had been removed by separating all that portion of the metal on which it had been exerted. Hence we may infer that the differences between length-sheet and cross-sheet specimens are really and truly ascribable to a difference of texture in the two directions, which will be seen to amount, in the case of filing in notches, to 6.15 per cent., and in that of filing to uniformity, to 6.26 per cent. of the strength of the cross-sheet specimens.

The single exception to the law that the greater strength is given in the longitudinal direction of the rolling, will be found explained in the remark appended to table XCV.

TABLE XCV.

Comparative view of the strength of specimens of ten different sorts of boiler and one of bar iron, in the longitudinal, transverse, and diagonal direction of the rolling, as deduced from the least

No. of the specimen referred to.	Strength in the longitudinal direction.	Strength in the transverse direction.	Specific gravity.
2	58977		7.7169
3	53828		7.7169
4	4714		7.7169
6		52280	7.7169
8		50103	7.7169
Mn.	53324	51191	
9	57952		7.7874
10	64133		7.7874
11	42000		7.7874
13		50488	7.7874
14		52542	7.7874
15		50166	7.7874
16		50039	7.7874
17		44249	7.7700
18		50218	7.7700
19		49125	7.7764
21	38618		7.7700
22	47491		7.7700
23	42798		7.7700
Mn.	48832	49546	
25	43921		7.7640
27	55636		7.7640
30		44703	7.7640
32		52197	7.7640
35	43237		7.7954
37	46155		7.7954
39		40595	7.7954
41		37713	7.7954
Mn.	47237	43802	
42	51653	Puddled.	7.6820
43	44102	do.	7.6820
44	53836	do.	7.6820
46	59262	H'd pla.	7.6785
48	59418	do.	7.6785
49	57565	do.	7.6785
51	H'd pl	59656	7.7567
53	H'd pla.	56062	7.7567
56	Puddled.	57926	7.6511
58	do.	50570	7.6511
59	48308	Puddled.	7.6013
60	58684	do.	7.6013
61	52869	do.	7.6013
62	57612	do.	7.6013
64	Puddled.	45392	7.6511
65	do.	51255	7.6511
68	57929	H'd pla.	7.7900
70	47638	do.	7.7900
71	H'd pla.	54634	7.7900
73	do.	52657	7.7900
74	do.	49351	7.7910
Mn.	54074	53049	
75	60408		7.7580
78	41734		7.7580
81		42903	7.7580
83		42162	7.7580
84		42696	7.7580
85	48694		7.7580
86	58969		7.7580
87	50249		7.7580
88	49508		7.7922
90		45060	7.7580
91		42365	7.7580
Mn.	51760	43037	
94		53811	
95		45471	
99		49548	
101	49258		
103		41319	
105		44591	
107		55461	
Mn.	49258	48366	
125	57182		
130	Tilted.		
133	do.		
135	do.		
137	do.		
Mn.	57182		
142	44399		
143	53135		
146	60594		
148			
149			
150			
151			
152			
154			
157			
160			
162			
164	56346		
167	56682		
169	54361		
171			
174			
Mn.	54253		
200			
201			
206	44149		
207	48120		
208	52175		
Mn.	48148		
226			
227			
228			
229			
230	49368		
Mn.	49368		

TABLE XCV.

Strength of each specimen, and the average minimum of each sort of iron, in each direction in which it was tried, together with the specific gravity of the several bars.

Strength in the transverse direction.	Strength in the diagonal direction.	Specific gravity.	REMARKS.
Tilted.			
57789			
53176			
	47738		
	50358		
55882	49048		
		7.7390	The only set of these experiments in which the bars cut crosswise of the sheet appear to be stronger than those cut lengthwise, is that from 9 to 23,—of which 3 of the length strips were from the same specimen,—a specimen in which a large flaky portion was developed by the trial. This set is therefore not to be taken into the account in computing the relative strength of the two classes of bars.
52468			
52228		7.7774	
56869		7.7774	
53811			
56073		7.7774	
	51134		
	52102		
			The specimens from 42 to 74, were partly puddled iron, and partly Juniata blooms, hammered and rolled into plate. The length and the cross-sheet specimens of these two kinds must be compared separately, as shown in the table (XCVI.) of general results.
53862			
50212			
	55612		
	51425		All the experiments on No. 228 (cross,) and 230 (length,) were made at ordinary temperatures with a view to this comparison.
53646	52568		
40163			
46970			
43566			
49053		7.7428	
53699		7.6675	
40643		7.6675	
46473		7.7428	
		7.6675	
47467			

TABLE XCVI.

General results of the several comparisons between bars cut in the different directions.

Sets of specimens compared.	No. of experiments on longitudinal bars.	Strength of specimens cut lengthwise.	No. of experiments on transverse bars.	Strength of specimens cut crosswise.	No. of experiments on diagonal bars.	Strength of bars cut diagonally.	Excess of longitudinal, over transverse specimens.	Excess compared with the whole strength of the cross cut bars as unity.
2— 8	3	53324	2	51191			2133	.0416
25— 41	4	47237	4	43802			3435	.0784
75— 91	6	51760	5	43037			8723	.2026
94—107	1	49258	6	48366			892	.0184
125—137	1	57182	2	55482	2	49048	1700	.0306
142—174	6	54253	7	53646	4	52568	607	.0113
200—208	3	48148	2	43566			4582	.1051
226—230	1	49368	4	47467			1901	.0421
Ham'd plate.	5	56366	5	54872			1894	.0347
Puddled iron.	7	52437	4	51411			1026	.0200
Mean of	37	51933	41	49247	6	50808	2689	.0585
Mn. of ex. on 228—230	13	54022	13	50433			3589	.0711

From the above comparison of nearly eighty specimens, from ten different sorts of iron, it appears that the average minimum strength of iron in the direction in which it is rolled, is very nearly 6 per cent. greater than that in the transverse direction.

Specific gravity of Boiler-Iron.

Table XCV. contains in addition to a view of the relative tenacities of strips cut lengthwise and crosswise of the boiler plate, a column exhibiting the specific gravities of the several kinds of iron there compared. In most cases, these were obtained by cutting from the same sheet which furnished the strips, and in a contiguous part, a small sample, expressly intended for a trial of its density. Several bars will consequently be found to have the same specific gravity assigned to them. But we have still no less than nineteen different experiments from which to deduce the general result. From these it appears that the highest density was 7.7922, the lowest 7.6013, and the mean 7.7344; also, that the difference .1909, between the maximum and the minimum is $\frac{1}{40 \cdot 3}$ part of the mean density, which may accordingly be taken as the limit of variations in this particular.

Seventeen different trials of specific gravity on *bar* iron gave a mean of 7.7254, and the greatest difference between any two results was 7.8319—7.4587=.3832, or $\frac{1}{20 \cdot 1}$ of the mean density.

Effect of repeated Piling on the tenacity of Plate-Iron.

The effect of repetitions of the process of piling and welding, whether of puddled iron or blooms, is exhibited in table XCVII., in which are contained the results of trials on three specimens of iron, furnished by an establishment in Centre County, Pennsylvania, a region known to afford an ore of superior quality, and which has long supplied wrought iron, inferior to few other kinds of the article known in the American market.

TABLE XCVII.

Experiments on bars No. 242, 243 and 244. Manufactured by Messrs. Valentine & Thomas, near Bellefonte, Centre County, Pa., from metal obtained from pipe ore, *found* 15 *miles north of that place. No. 242 from "refinery bloom", extended into bars three inches wide by one inch thick, piled four high and twice welded. No. 243 also from "refinery bloom," twice welded. No. 244 manufactured from puddled iron, rolled at the first operation into* 3½ *by* 1 *inch, then cut up and piled* 4 *tiers high, welded again and extended into a billet, then a second welding and rolling into the shape in which it was received.*

No. of the bar.	No. of the experiment.	DATE.	Breadth before trial.	Thickness before trial.	Area of section before trial.	Breaking weight in the scale.	Breaking weight × leverage.	Friction.	Effective strain.	Strength in pounds per square inch.	REMARKS.
242	1	1835, Nov.	.753	.222	.167166	342	10260	513	9747	58308	All the bars had been reduced when received to such a state of uniformity in size as allowed them to be considered as equal throughout and equal to each other. The experiments on 242 prove that the mean str'gth is 59247 lbs., and the irregularity between experiments 1 and 3 is 2047, or a little more than 1-29 of the mean strength.
"	2	"	do.	do.	do.	349	10470	523	9947	59505	
"	3	"	do.	do.	do.	354	10620	531	10089	60355	
"	4	"	do.	do.	do.	345	10350	517	9833	58820	
243	5	Nov.	.753	.222	.167166	340	10200	510	9690	57972	From experiments on this bar it appears that the mean strength was 58787 lbs., the difference between experiments 1 and 5 is 2718 or the irregularity amounts to 1-21.6 part of the mean strength.
"	6	"	do.	do.	do.	340	10200	510	9690	57972	
"	7	"	do.	do.	do.	343	10290	514	9676	58480	
"	8	"	do.	do.	do.	345	10350	517	9833	58820	
"	9	"	do.	do.	do.	356	10680	534	10146	60690	
244	10	Nov.	.753	.222	.167166	332	9960	498	9462	56600	From these experiments it is seen that the mean strength of the puddled bar was 57513 lbs.—the greatest difference, that between experiments 1 and 6, is 2390, or almost exactly 1-24 of the mean strength.
"	11	"	do.	do.	do.	335	10050	502	9548	57115	
"	12	"	do.	do.	do.	335	10050	502	9548	57115	
"	13	"	do.	do.	do.	336	10080	504	9576	57285	
"	14	"	do.	do.	do.	340	10200	510	9690	57972	
"	15	"	do.	do.	do.	346	10380	519	9861	58990	

Results.—1. The specimen which had been made from *refinery bloom* reduced to a bar 3 inches wide by 1 thick, piled 4 high and twice welded, proved the strongest. Not only did it exhibit the high mean result of 59247 pounds to the square inch, but the consistency and uniformity of the metal were such as to show between the highest and the lowest results a difference amounting to only 3.4 per cent. of that mean.

2. The specimen which had undergone two weldings, but had not been drawn into a bar and piled, was inferior to the preceding, giving a mean result of 58787; and the difference between the extremes exceeds 4.6 per cent. of that amount.

3. The specimen manufactured from puddled iron, rolled at the first operation into a bar $3\frac{1}{2}$ inches wide by 1 inch thick, cut and piled 4 tier high and then twice welded and rolled into bars little more than $\frac{7}{10}$ of an inch in thickness, was obviously designed by the manufacturers to correspond in all particulars with No. 1, except that the latter was from the bloomery, and the other (No. 3.) from the puddling furnace. The mean absolute strength of this specimen was decidedly less than that of either of the preceding, being only 57613 pounds, while the variation from uniformity was 4.1 per cent. of its mean strength.

Effects of Piling into the same Plate, Iron of different degrees of fineness.

It is believed to be a practice, not unknown among the manufacturers of boiler iron to combine into the same slab, and subsequently to roll into plate, iron of different qualities. In such cases the want of homogeneousness may manifest itself in a variety of ways. The different kinds may not be equally welded together throughout, and may consequently exhibit flaws at the surfaces of lamellation. They may be very unequally extensible under the same force, and while the outer ply of metal may, in turning a flanch, remain unbroken, the interior one may be greatly reduced in strength. They may be of different specific gravities and mislead the purchaser, who looks only upon the exterior face of the plate, and judges of its value by the good appearance of the latter, and the weight of the whole per square foot under a given thickness.

By a reference to table XXXIII., in experiments on bars 39 and 41, it will be seen that a considerable defect, of the nature above alluded to, was exhibited, and the low results given in those cases, (40600 and 37700 lbs. per square inch) afford conclusive evidence of the bad quality of boiler plate in which such defects of welding between the laminæ exist.

In table XLIX., experiment 16, another example of the same kind occurs, in which a decided difference of appearance in the fracture showed itself between the interior and exterior folds of the metal.

Effects of the Rivets on the Total Strength of Boilers.

In whatever manner the parts of a steam boiler are united, the rivets which form the junctures being substituted for portions of the metal cut away to receive them, are of necessity so much deduction from the strength of the entire sheet, and unless we can suppose that the strain brought upon the rivet by the manner of setting it, when hot, and in that state making so close a bearing as, when cold, to contract and create a pressure that shall furnish an adhesion by friction between the overlapping surfaces, equal in amount to the strength taken away by the line of rivet holes, we cannot in

computing the absolute strength of any steam boiler, safely rely on more than the portion of metal which remains in the intervals between the holes. That the requisite amount of friction could not, under the circumstances which practice assigns to the case, be produced in the manner supposed, is easily demonstrable, since, for that purpose, the friction on two square inches of surface, (the amount which on each side of the line of rivets could possibly be available for this purpose,) must be equal to the strength of the part cut away, which seldom falls short of $\frac{5}{8}$ of an inch. If we could suppose the rivet of this size so strained by hot working and shrinking as to exert $\frac{3}{4}$ of its entire strength or what would be just sufficient to produce in it a permanent elongation, then as its area of section would be .3068 of a square inch, admitting the iron of which it was made to be capable of bearing 55000 lbs. to the square inch, we should have an actual pressure of $55000 \times \frac{3}{4} \times .3068 = 11249$ pounds to be distributed over 4 square inches, giving for each of the two sheets 5624 pounds of pressure, the *friction* of which is to counteract the cutting away of $\frac{5}{16}$ of its substance.

If we suppose the plate to have the same strength per square inch as the rivet, and $\frac{1}{4}$ of an inch in thickness, two-thirds of the strength of the part cut away ($\frac{5}{8}$ of an inch wide,) would be 5726 pounds. From this it is evident that for a weakening of 5726 pounds, we have only the compensation of the *friction* produced by a pressure of 5624 pounds. That fractures not only do take place along the lines of rivets when violent explosions occur, but that incipient fractures and permanent elongations are presented at the spaces between the rivet holes, is evinced by the appearance of the holes themselves elongated by strains and especially by overheating in the vicinity of the juncture. Examples of this are found in Table XCVIII.

In a piece of boiler iron which had been some years in use, and which from overheating, in consequence of the collecting of a quantity of sediment in the part immediately above the fire, had become locally swelled into a protuberance reaching nearly the breadth of a sheet and from nine to ten inches in the direction of the curve, the rivet holes on both sides of the sheet, opposite to the protuberance, were found to be elongated as in the following table. All those on the side nearest to the summit of the protuberance, were found to have cracks running out in different directions, and in some cases, nearly traversing the entire space between the two adjacent rivets. (See the figure, page 238.)

Within half an inch of the first five rivets, and parallel with their line, a strip *a*, one inch wide, was cut from this piece of boiler, and tried at several filed sections. The report of these trials will be found in Table C. from which it will be seen that the portion nearest to the protuberance, and which had been reduced in thickness by the stretching, possessed much less strength *per square inch* than that which was still of the original thickness of the sheet. The surface of this bar, when the oxide had been removed, presented a distinctly spongy or *honey-comb* appearance, having many minute cells, which being developed by the shears were seen to be nearly filled up with oxide. The committee took an opportunity of making direct trial of the diminution of strength by rivetting. A bar of iron $\frac{9}{10}$ of an inch wide and .134 inch in thickness was rivetted together at a lap six inches long, by 12 rivets, each .205 inch in diameter, in two rows along the length of the bar, but alternating with each other in a zigzag course, the rivet near one edge being about one-third of an inch in advance, along the length, of the preceding one on the opposite edge.

TABLE XCVIII.

Effect of unequal strains on rivet holes.

No. of rivet holes.	Position of the rivet holes.	Length of the major axis of the rivet hole lying in the direction towards the swelled portion.	Length of the minor axis transverse to the swell, and in the line of the series of rivets.	REMARKS.
		Inch.	Inch.	Refer to fig., page 238.
1	At the part of the plate nearest to the swelling.	.750	.700	The centre of the rivets in this piece of boiler iron were 2 inches apart. Two cracks proceeded from this hole, one towards the interior of the sheet 4-10 inch long, the other towards the next rivet, 9–10 inch long.
2	Do.	.735	.650	An oblique crack proceeding gradually towards the interior but more rapidly to the next rivet, 9-10 inch long.
3	Do.	.740	.700	Crack proceeding towards the next rivet ⅞ inch in length.
4	Do.	.705	.670	Two cracks proceeding in opposite directions, one 2-10 inch, the other 3-10 of an inch.
5	Do.	.750	.705	These cracks proceeding from the periphery of this hole, each from 3 to 4 tenths of an inch in length.
6	At the part of the plate most remote from swelling.	.725	.700	No cracks observable.
7	Do.	.715	.700	Do.
8	Do.	.675	.645	Do.
9	Do.	.690	.665	Do.
10	Do.	.665	.665	This hole appears to be the only one which retains its original size and shape.

The above described compound bar broke with an oblique section 1.05 inch long, passing through two rivet-holes.

The *strength* computed on the area of *cross* section was 52580 pounds, which reduced to the area of the actual oblique section is 45068 per sq. inch.

The same bar afterwards broken at a point six inches from the foregoing fracture, exhibited a strength of 66027 pounds. If we conceive the diameters of two rivets deducted from the cross section there remains but .49 of an inch in the breadth of the strap of iron which supported an effective strain of 6341 pounds. But the diagonal section of fracture had an area, after deducting the diameters of two rivet holes, of .64×.134=.08576, whereas at the place of fracture, six inches distant, the area was .113529. The effective strain which broke the bar in this latter case was 7496 lbs. Applying this as a standard to the actual section of fracture at the rivets, we have the following calculations:—

1. For the weakening effect of cutting away the metal at the rivets; .113529 : .1407 : : 7496 : 9290=the effective strain which would have been borne by a section of this metal, 1.05 inch wide and .134 inch thick, had none been cut away to make room for the rivets. But the actual area left was

only .08576. Hence .113529 : 08576 : : 7496 : 5662 which ought to have been borne if no strengthening influence had been exerted by the rivets. The difference, or 9290—5662=3628, is the reduction of strength by cutting out the two cylindrical holes; but the actual effective strain was 6341. So that the weakening effect is in fact 9290—6341=2949.

2. The strengthening effect of the friction is 6341—5662=679.

Construction of Cylindrical Boilers and Flues.

In connection with the subject of rivetting it may be remarked, that unless a due regard to the form of the parts of a boiler be observed in constructing it, and a due attention to the rivet holes in the different pieces, the strains incidental to the boiler in its regular use, may be made more dangerous than that which would arise from the mere elastic energy of the steam alone. The usual practice in constructing cylindrical boilers and flues is to make the portions in the form of frusta of cones, the smaller end of one of which entering the larger end of the next, is rivetted in such a manner as to turn all the outer laps in the direction of the *fire end* of the boiler. It is evident that in such a construction the several plates which constitute a single ring of the boiler must have the lines of rivets along their *ends* placed in converging *right lines* and those along the sides or longest edges, in circular arcs of different radii. If in any case these lines are inconsistent with the positions of others to which they are required to conform, the holes must either be rimmed out, or the sheet unduly strained in attempting to force a conformity of positions.

In every case in which a just construction by the aid of previous calculation is obtained, the centres of the rivet holes are the points from which our calculations must commence.

It is obvious that the diameter of the cylindrical, or rather of the compound conical, shell, must constitute one element of the calculation, the breadth of the sheets a second, and the thickness of the metal a third. From these data may be found the radii of the curves in which are to be placed the rivets, and also the convergency of the two straight lines along the two ends of each sheet. The difference in the exterior diameters of the two ends of each frustum must at their respective rivet-lines be equal to twice the thickness of the metal. The larger arc for the rivet holes must manifestly be described by a longer radius than the smaller, and the difference of the two radii is the breadth of the sheet between the curves.

The larger radius will in every case be found *by adding to the mean exterior diameter of the boiler in inches, the thickness of the plate in the same denomination, multiplying the sum by the breadth of the plate, and dividing the product by twice the thickness of the plate.**

Effects of use and long exposure on the strength of boiler-iron.

This topic may be regarded as one of the most important which came under the notice of the committee. To treat it in all its bearings would demand far more of time and means that were at our disposal.

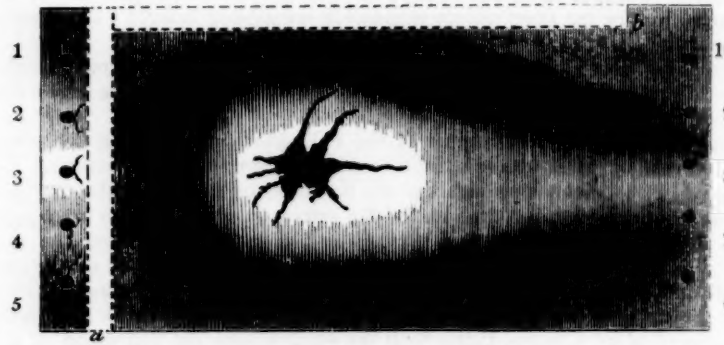
* Thus putting D=the exterior diameter of the boiler,
t =the thickness of the metal,
b=the breadth of the sheet between the two arcs of rivets,
A=the length of the greater arc which will reach round the larger end of the frustum,
a= " less Do.
R=the radius of the greater arc,
r= " less; so that $R-r=b$,
also $\pi=3.1416$.

Table C. contains the results of trials on four bars or strips cut from pieces of plate which had been long in use, and which were more or less visibly affected by the strain, or by the action of water and steam to which they had been subjected. They were cut lengthwise and crosswise respectively from the sheets out of which they were taken, one bar in each direction out of each sheet.

The two strips, Nos. 245 and 246, taken from a specimen of plate which had been burst, are represented in position by the dotted lines in the accompanying sketch. The length of the specimen is the original breadth of the sheet and lay as usual in the direction of the length of the boiler, 30 inches in diameter, from the bottom of which near the fire-end this piece was taken. Hence the shorter strip (a) is a length sheet strip, and the longer (b,) a cross sheet strip.

Agreeably to what has already been shown, the former possessed the greater strength, but the second experiment upon it made at the point m, where the swelling commenced, was found, as shown in the table, considerably weaker than the sections near the two ends of the strip.

The amount of the swelling on this specimen of iron may be seen by the two sketches, page 239, one of which is longitudinal and the other transversal, and the lengths of the ordinates, from lines at right angles to each other, and both passing over the centre of the swelled part, at b will be found in the



Then, since the arcs are similar, $A : a :: R : r$ and $A - a : A :: R - r : R$. But $A = \pi\ (D+t)$ and $a = \pi\ (D-t.)$ Hence $A - a = \pi\ (D+t) - \pi\ (D-t) = 2\pi t$. Hence by the above proportion and putting b for $R - r$ we obtain $2\pi t : \pi\ (D+t) :: b : R$, from which results $R = \frac{b(D+t)}{2t}$, and $r = \frac{b(D+t)}{2t} - b$. As there must be the same number of rivet holes in each arc, a knowledge of the lengths of the respective arcs and of the number of rivets to be placed round the boiler, determines their distances from each other, on the two curves respectively. The accompanying figure represents the arrangement of the rivet-holes in a plate of metal adapted to constitute a part of a cylindrical boiler, with the centre c, and radii cy and cx of the two arcs of rivet-holes.

accompanying table. The ordinates on the inside or concave part of the plate, commence Fig. 1 from the centre of the rivet holes nearest to the place of rupture *b*. The points on the two axes were 1.075 inches apart.

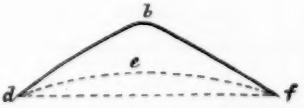
TABLE XCIX.

No. of mark on the line lengthwise of specimen.	Ordinate or distance of the line from the bottom of the cavity in inches.	REMARKS.	No. of mark on the line transverse to the curvature of the piece.	Ordinate or distance from the co-ordinate to the inner surface of the swell.	REMARKS.
1	.150		1	.700	
2	.500		2	1.425	
3	.945		3	2.200	
4	1.430		4	2.720	The rupture was opposite to these marks.
5	2.000		5	2.960	
6	2.075	The rupture was opposite to these marks and the distances could not be measured with the same precision as the rest.	6	2.320	
7	2.350		7	1.745	
8	1.975		8	0.940	
9	1.870		9	0.390	
10	1.600		10	0.000	
11	1.360				
12	1.115				
13	0.940				
14	0.665				
15	0.520				
16	0.395				
17	0.350				
18	0.265				
19	0.145				
20	.080				

The original distance in the line *ac*, Fig. 1., was $22\frac{1}{2}$ inches. The length of the curve *abc* by actual measurement was found to be 24.6 inches. Hence the extension of the metal in this direction had been 2 1-10 inches in 22 5-10 or $\frac{1}{10.7}$ of the whole length.

Fig. 1.

Fig. 2.



The length in the direction of the curve *def*, Fig. 2., was originally 10.6 inches. Actual measurement over the curve *dbf*, gave the length 12 inches, showing an elongation of fibres in this direction equal to 1.4 inches in 10.6 or $\frac{1}{7.5}$ of their whole original length. This greater extension of the fibres in the longitudinal direction of the sheet, accords with what has already been proved by direct trials on bars cut from new plates.

TABLE C.

Experiments on old boiler iron, Nos. **97, 98, 245** *and* **246.** *The two former manufactured by Lukens, and the two latter uncertain, all having been some time in use, and visibly affected by the action of heat*

No. of the bar.	No. of the exp't.	DATE.	Breadth of the section of fracture before trial.	Thickness of the section of fracture before trial.	Area of the section before trial.	Temperature.	Breaking weight.	Breaking weight × leverage.	Friction.
		1836.							
97	1	Feb. 13.	.785	.197	.154645	45°	273	8190	409
"	2	"	1.000	.215	.215000	45	349	10470	523
"	3	"	1.100	.100 / .200	.165000	45	282	8460	423
"	4	Feb. 27.	.736	.217	.159712	41	285	8550	427
98	5	Feb. 13.	.720	.194	.139680	45	238	7140	357
"	6	Feb. 27.	.705	.214	.150870	41	275	8250	412
"	7	"	1.000	.182	.182000	41	338	10140	507
"	8	"	1.051	.220	.231220	41	373	11190	559
245	9	Mar. 21.	.661	.165	.109065	50	207	6210	310.5
"	10	"	.732	.141	.103212	50	170	5100	255
"	11	"	.731	.181	.132311	50	228	6840	342
246	12	Mar. 26.	.704	.182	.128128	51	206	6180	309
"	13	"	.721	.182	.131222	51	219	6570	328
"	14	"	.686	.182	.124852	51	212	6360	318
"	15	"	.693	.183	.126126	51	231	6930	346.5

TABLE C.

or corrosion. The two latter were from a specimen in which was a rupture in consequence of the collection of a sediment over the part exposed to the fire.

Effective strain.	Strength in lbs. per square inch.	REMARKS.
7781	50314	This strip was cut crosswise of the sheet,—filed section, edges and faces both filed.
9947	46265	Original section produced by the shears.
8037	48103	Fracture at a part deeply corroded. The thinnest place before trial was found but one-tenth of an inch thick.
8123	50860	The edges of this section of fracture were deeply filed, and the oxide was removed from the faces of the bars.
6783	48561	Filed on both edges and faces. Cut lengthwise.
7838	51952	Filed deeply on the edges. Oxide barely removed from the faces.
9633	52928	The edges barely straightened, much filed on the faces.
10631	45982	Edges barely straightened by filing—faces unfiled.
5989.5	54000	Deeply filed on the edges. Oxide removed from the faces. This strip cut lengthwise of the rolling.
4845	46942	This part of the bar had been over-heated, and stretched. Deeply filed as above.
6498	49111	Deeply filed, and oxide removed.
5871	45821	This strip cut crosswise from the ruptured specimen. (See figure on page 238.) Filed and scale removed.
6242	47568	Filed and cleared of oxide as above.
6042	48465	Do.
6583.5	52205	Do.

The two specimens, Nos. 97 and 98, Table C., were deeply corroded in certain parts, indicating the existence of local chemical actions arising probably from inequalities in either the purity, or the mechanical structure, of the sheet.

In both sets of the above trials on old boiler-plate it will be observed that though the mean strength is low, being under 50000 pounds per square inch, yet the principle is still preserved which assigns a greater tenacity in the longitudinal than in the transverse direction of the rolling. The difference, in this respect, between Nos. 245 and 246 is 50017—48515 or 3 per cent. of the strength of the transverse strip.

Between Nos. 97 and 98 the difference is somewhat less.

Effect of Annealing on the tenacity of Iron.

In a variety of cases the committee have endeavoured to extend the range of their experiments so as to embrace the condition of a steam-boiler which without being exploded has suffered from the exposure of its fire-surface when destitute of a due supply of water, to the action of heat above redness. In a few of the trials at elevated temperatures, this point was attained or surpassed, and the subsequent trials on parts near the places of fracture in such cases, gave evidence that the condition of the metal in regard to tenacity had been altered. In the case of bar No. 13, Table XXXI., it will be observed that annealing, which in that instance was produced by the folding over of the ends of the bar to obtain a more certain hold by the wedges, determined at once the place of fracture.

On specimens 199 B and 199 C, Table CII., which were wires manufactured at Phillipsburg from Juniata iron, were made several experiments to ascertain its mean tenacity, in the ordinary state of the article. On other pieces of the same wires the process of annealing at high temperatures was performed. The results show that the maximum effect of annealing on one of the sizes was a diminution of 27.5 per cent., and on the other 46 per cent. of the original strength.

In these instances the annealing was performed in a common smith's fire, without using any other precaution to defend the wire from oxidation than merely covering it with cinder.

This prevented, for the most part, any action of the air on the wire during the short time of its remaining in the fire. But to obviate altogether the objection that oxidation might have some share in producing the weakening effect, several specimens of iron were, after being carefully gauged, weighed and, having their specific gravities taken, rolled up in several folds of clean sheet iron; the ends of the folds turned over and hammered flat, to prevent access of air, and the whole then exposed for 15 or 20 minutes to the blast of a smith's fire, gradually raising it to a very high *welding heat*. In this state the package was withdrawn from the fire, often exhibiting one or two folds of the sheet iron cut through by the blast, but in no case extending to the enclosed specimens. When taken from the fire it was immediately buried in dead cinders, where it was allowed to remain until quite cold. The wrapping of sheet iron was then removed, and the specimens generally found with no visible change except a slight discolouration by black oxide of the metal, insufficient, however, to affect sensibly the weight of the specimen.

The five trials on Nos. 224 C and 254 D were among those which had been reduced or *constricted* by straining before the specimens were annealed.

TABLE CI.

Wrought iron annealed at different temperatures.

No. of the comparisons.	No. of the specimen on which the trial was made.	No. of the table containing the results on each specimen.	Strength at ordinary temperature before annealing.	Temperature at which the annealing took place.	Strength at the annealing temperature.	Strength after annealing and cooling.	Rate of diminution in strength by annealing.
1	152	LI.	57133	1037°	37764	55678	.025
2	214	LXII.	59219	1022	37410	46612	.213
3	227	LIV.	53774	1111	27604	52186	.029
4	226	LIII.	52040	1142	18672	44720	.140
5	227	LIV.	53774	1155	21967	45597	.152
6	229	LVI.	53185	1159	25620	46212	.131
7	227	LIV.	53774	1187	21919	45027	.162
8	226	LIII.	52040	1192	29703	43154	.170
9	226	LIII.	52040	1237	21298	44165	.151
10	226	LIII.	52040	1245	20703	38843	.253
11	224C.	LXXII.	48407	Bright welding heat.		36052	.255
12	224C.	LXXII.	48407	Do.		39333	.187
13	224D.	LXXIII.	48830	Do.		35889	.265
14	224D.	LXXIII.	48830	Do.		36706	.248
15	224C.	LXXII.	48407	Do.		38676	.201
16	19	XXXII.	52912	Do.		44191	.165
17	199B.	CII.	73880	Low welding heat.		53578	.275
18	199A.	LXIV.	76986	Bright welding heat.		50074	.349
19	199C.	CII.	89162	Low welding heat.		48144	.460

TABLE CII.

Experiments on two specimens of wire, Nos. 199 *B. and* 199 *C. Manufactured at Phillipsburg, Pa., from Juniata iron. One specimen*

No. of the exp't.	Diameter of the wire.	Area of section of the wire before trial.	Temperature when tried.	Breaking weight in the scale.	Breaking weight × leverage.	Friction of the machine.	Effective strain.
	inch.	square inch.					
1	.190	.0283526	70°	73.	2190	109.5	2080.5
2	do.	do.	70	73.	2190	109.5	2080.5
3	do.	do.	70	74.5	2235	111.7	2123.3
4	do.	do.	70	74.	2220	111.	2109.
5	do.	do.	70	73.	2190	109.5	2080.5
6	do.	do.	76	49.5	1485	74.2	1410.8
7	do.	do.	76	54.5	1635	81.7	1553.3
8	do.	do.	76	62.	1860	93.	1767.
9	do.	do.	76	61.5	1845	92.2	1752.8
10	do.	do.	76	61.5	1845	92.2	1752.8
11	do.	do.	76	52.	1560	78.	1482.
12	do.	do.	76	53.5	1605	80.2	1524.8
13	do.	do.	76	52.5	1575	78.7	1496.3
14	do.	do.	76	54.	1620	81.	1539.
15	do.	do.	76	54.5	1635	81.7	1553.3
1	.156	.0191127	76	60.	1800	90.	1710.
2	do.	do.	76	60.	1800	90.	1710.
3	do.	do.	76	59.5	1785	89.7	1695.3
4	do.	do.	76	60.	1800	90.	1710.
5	do.	do.	76	59.5	1785	89.7	1695.3
6	do.	do.	77	32.	960	48.	912.
7	do.	do.	77	32.5	975	48.7	926.3
8	do.	do.	77	32.5	975	48.7	926.3
9	do.	do.	77	33.5	1005	50.2	954.8
10	do.	do.	77	33.5	1005	50.2	954.8
11	do.	do.	77	34.5	1035	51.7	983.3
12	do.	do.	77	35.	1050	52.5	997.5

TABLE CII.

of each size, broken up cold, and without annealing, the others annealed and cooled, either in cinders or in water.

Strength in lbs. per square inch.	Mean strength in each state.	REMARKS.
73379		The first five experiments were made on specimen 199 B, of the wire, unannealed.
73379		
74880		
74386		
73379		
	73880	
49760		This and the four following experiments were made on a specimen of the wire of about the same length as the above, annealed by heating to redness, and then buried in dry ashes until cold.
54786		
62323		
61819		
61819		Broke in the gripe of the wedges.
	58101	
52268		This and the four following were made on a specimen of the same wire as the two above mentioned, annealed at redness and immediately quenched in cold water.
53781		
52775		
54281		
54786		
	53578	
89469		This and the four following experiments, were on the smallest size of wire, 199 C., in its unannealed state.
89469		
88703		
89469		
88703		
	89162	
47714		This and the two following were made on wire of the same size, and from the same piece as the above, annealed and buried in ashes.
48360		
48360		
	48144	
49958		This and the three following were on the same size of wire, annealed and immediately quenched.
49958		
51449		
52192		
	50889	

No essential change of specific gravity from annealing was detected, except in the case of a piece which had been beforehand excessively hammer-hardened. This appeared to have been slightly diminished in density by the annealing process. When the specimens treated in this manner had been previously strained nearly to the limit of their tenacity, and their original areas of section consequently much reduced, the precaution was taken to regauge them before annealing, so that we could employ the then existing areas of section, instead of the original ones, as the basis of calculation for the strength per square inch. This course was followed with Nos. 224 C and 224 D.

Calculating the strengths on the areas of these bars taken just before annealing, they were found as follows:

Instead	of	36052	we	obtained	45090,
"	"	39333	"	"	41980,
"	"	35889	"	"	42700,
"	"	36706	"	"	43200,
"	"	38676	"	"	41980.

From table CI. it appears, that, computing the strength in the comparisons from 11 to 15 inclusive on the area before annealing, and excluding Nos.1 and 3 of the series, as not made at a sufficiently high temperature to effect the purpose, we get the mean tenacity of iron, by seventeen comparisons after annealing, equal to 45117 lbs. to the square inch.

In a considerable number of cases where trials were made at high temperatures, especially those above 1000°, the iron was left in an annealed state. In several of these the effect of the process is nearly as striking as where the heating had extended to the point of welding.

In other cases the difference between the strength previous to annealing, and that exhibited afterwards, was so small, that it was difficult to refer it to any other cause than the original inequalities of structure.

It will be seen that, from Experiment 3 to Experiment 11 (Table CI.) the loss of tenacity by annealing follows very nearly the order of the temperatures at which the process was performed.

That boilers do, in the course of ordinary practice, frequently become annealed there can be litle doubt. The four specimens of old boiler-iron already spoken of, indicate clearly the existence of such a state. The mean strength of those specimens by 15 experiments was 49278 lbs., while the mean minimum strength of the four bars was 46252, quite within the range of the tenacity of iron annealed at a red heat. Hence, unless we can be certain that a boiler will be entirely secure from this process, we shall not be warranted in calculating its strength at any greater amount than about 46000 pounds per square inch, and of this amount but two-thirds can be assumed as a safe basis of calculation, being that at which permanent change of form would take place.

Your sub-committee have at length brought to a conclusion the research which has so long* occupied their attention. The foregoing pages present as concisely as the case seemed to admit, the facts which their investigations have elicited, in regard to the several inquiries, Principal, Incidental and Subsidiary, stated in the preliminary part of this report. The great interest of the subject required that the utmost care should be

* This sub-committee was appointed January 4, 1831, and preparations for the experiments immediately prosecuted.—The trials of tenacity were commenced April 4, 1832. The last experiments were made January 5, 1837.

exercised to prevent error. Hasty and unwarrantable conclusions were to be avoided. It has been our sincere desire to meet every just expectation in regard to the practical usefulness of the information of which we were in search. It would be presuming too far to suppose that in so extensive a mass of calculations we had escaped all error. So many steps of each process have, however, been preserved, that verifications will be easily made. Speculations, merely scientific, have been deemed inappropriate to this report, and we now abstain from swelling it with repetitions of statements already made, or with any matters not strictly pertinent to the subjects embraced within the views of the general committee.

WALTER R. JOHNSON.
BENJAMIN REEVES.

N. B.—Prof. A. D. Bache, the remaining member of the sub-committee, being absent from the country at the time of making this report, we regret that it is impracticable to submit it to him for inspection and signature.

In the course of this inquiry we have been indebted for valuable personal assistance to several friends of the useful arts, among whom we would particularly mention the late Benjamin Say, Esq., and Messrs. James M'Crea, James Barnet and Joseph Brezinski. The last named gentleman repeated and verified many of the calculations as well as aided in various experiments.

Note.—Mr. Telford has made an interesting series of experiments on the strength of wire, an account of which is found in Mr. Barlow's treatise on the strength and stress of timber, page 254.

The same gentleman made various experiments on bars and bolts of iron, detailed in the same work.

He also attended to the successive elongations of bars under different weights, and noted the amount of recoil or contraction when relieved from strain.

Captain S. Brown has also furnished to Mr. Barlow, a series of highly interesting experiments on the strength and elongation of iron bolts.

The mean result of three experiments by Mr. Brown on cast-iron was 18564 lbs. to the square inch.

Mr. Hodgkinson has published in the third report of the British Association, three results of experiments on the same material, which make its strength 17136 lbs. per square inch, while the three experiments of the committee of the Frank. Inst., which were considered fair, indicated in the bars a strength of 20834 lbs.

Mr. Brunton and Mr. Brunel, have each engaged in this interesting department of inquiry and given the results of experiments on a large scale which will be found in the work of Mr. Barlow already cited.

Mr. E. Martin, formerly of the Polytechnic school, has given in the Annales des Mines, Vol. V., a series of experiments executed in France, under the orders of M. Barbé on round rods of iron, 18 or 19 feet long and 2 inches or more in diameter, made with a view, in part, to determine the recoil when released from strain, and the actual amount of elongation under each weight to which it was subjected.

In the same volume of the Annales des Mines, M. Vicat has a paper referring to, and controverting some of the positions of M. Martin, but not affecting the statements respecting the experimental operations just referred to.

In the same work, Vol. VI., are contained some interesting statements by M. Payen, respecting the manufacture of wire, in which the relative ductility before and after annealing is established.

In the Annales de Chimie et de Physique for Sept. 1833, is a valuable paper by M. Vicat, showing the influence of time on the gradual extension of wires under different weights. Each of his experiments occupied nearly three years.

The quantity by which iron extends under different degrees of tension, and on the recoil when relieved from strain, has been examined by Prof. Barlow. See Journal Fran. Inst. Vol. XVI. p. 124, &c. The relation between the effect of straining and elongating a bar by mechanical means, and that of expanding it by heat, is also noticed.

Physical Science.

Experiments on Solar Light. By JOHN W. DRAPER, M. D. Professor of Chemistry, Hampden Sidney College, Va.

(Continued from p. 38.)

68, *List of metallic salts changed by light.* 69, *Analysis of the dark chloride of silver.* 73, *Action of moonlight and artificial lights.*

74, *Perihelion motion of matter.* 76, *Doubtful if it be always the same.* 77, *Modes of making these experiments.* 80, *Dew of water.* 81, *Dew of mercury.* 82, *Iodine.* 83, *Chloride of gold.* 84, *Non-deposition on a glass plate.* 86, *Current action.* 88, *Action of terrestrial flames.* 91, *Temperature of sides of a jar.* 92, *Modification of light by reflexion.* 93, *Action of a metal screen.* 95, *Protecting action of a metallic ring.* 102, *Action of non-conducting bodies.* 104, 106, *Electricity obtained from the solar ray.* 110, *Explanations founded on that hypothesis.* 112, *Determination which class of rays causes this perihelion motion.*

68. The chemical rays, thus closely attending the luminous rays, and being like them subject to the forces bringing about reflexion, refraction, and inflexion, it would become a matter worthy of inquiry, to find whether there be any different classes of these rays, analogous to the different coloured rays of light, or the unequally refrangible and absorbable rays of heat. The salts of silver, are only one of a class over which the chemical rays exert an action. The following list contains, I believe, all the metallic salts, at present known, in the constitution of which changes are brought about by exposure to the sun.

Chloride of manganese,	Iodide of mercury,
Sulphocyrate of iron,	Chloride of mercury,
Sulphate of nickel,	Bichloride of mercury,
Carbonate of lead,	Chloride of silver,
Carbonate of nickel,	Bromide of silver,
Nitrate of bismuth,	Sulphocyrate of silver,
Chloride of uranium,	Nitrate of silver,
Sulphate of uranium,	Bromate of silver,
Nitrate of uranium,	Chloride of gold,
Chloride of copper,	Chloride of osmium and potassium.

Besides which, there are two others whose constitution is not well known; one prepared from an alcoholic solution of the double chloride of platinum and sodium, by the action of chloride of potassium, and the other in a similar manner from the cyanide of platinium.

69. The changes which these bodies experience, are of different kinds, some become black and some bleach; some, as the sulphate of nickel, undergo change of crystalline arrangement. If we are to take the chloride of silver as a type of those bodies in this list, which undergo partial reduction, it will be found probable, that the change impressed on them is only superficial, as analysis will show. But we cannot tell with certainty, whether a perfect reduction of some of these compounds takes place, or whether it is a subsalt of a dark grey colour that results. By taking advantage of the property which chloride of silver possesses, of subsiding very slowly from neutral solutions, so as to make them assume a milky consistency, we may present it in a state extremely favourable to the action of the solar ray. For if a thick mass alone be exposed, the central parts will not undergo the same change as the exterior, being shielded by them

from the sun. A milky solution like this will, after an exposure for a certain time, become quite clear, the chloride precipitating, owing to the liquid becoming acidulous. Mechanical agitation being then resorted to, to expose fresh surfaces of the precipitate to the sun, very frequently during a period of eight or ten days, and care being taken to suffer no dust or other impurity to enter the vessel, it will be found that the powder has become of a reddish grey, interspersed with little particles of unchanged white chloride; these, from their superior density, will have precipitated more readily than the grey particles; washing and decantation will therefore readily effect a perfect separation of them. One hundred grains of the dark chloride thus treated, will yield an analysis 79.3 of metallic silver; that quantity contains therefore 20.7 of chlorine, it has lost then by exposure 5.3 grains of chlorine, of the quantity originally contained in it.

70. Other analyses of the same sample, furnished results not widely varying from this, but such is not the case with analyses of different samples, these give sometimes more, sometimes less, chlorine, they prove that the chloride of silver as darkened by light, is not a definite compound, but rather a mechanical mixture; that the change of composition is chiefly confined to the surface, and does not affect the interior of the particles to any extent; it is true, that microscopic observation shows them to have an uniform consistency and colour, but of course reveals nothing of their internal character. An error is frequently made by writers who describe the changes happening in this partial reduction; it is not, as they say, hydrochloric acid which is evolved when the chloride is under water, but it is chlorine, as is made very evident by the strong disagreeable odour of that gas when the experiment is conducted in close vessels.

71. In addition to the list given above of substances changed by the chemical rays, there are some others which exhibit their energy in a very marked manner. Chlorine and hydrogen unite together with an explosion; carbon and chlorine are also made thus to unite, in producing the per-chloride of carbon; all kinds of vegetable colours are bleached; hydrodide of carbon and chloro-carbonic acid are always made by the action of solar radiant matter.

72. It has been stated by some chemists, that whilst the violet extremity of the solar spectrum blackened cloride of silver, there are other parts of it which would bleach the salt so blackened; but it is not so, for neither does any part of a very dispersed spectrum, nor the rays which have passed through a variety of absorbing media, exert such an action. These experiments I tried repeatedly, under all the conditions of variation of temperature and brilliancy of the solar rays, but no observation led to the inference that there was any change of colour, or any sign of an approaching change, even after the lapse of a whole month. Indeed, it would seem that the state of this case does not justify any such expectation; when the chemical rays have disunited the chlorine, it is gone and lost forever to the silver, being scattered abroad in the atmosphere; if therefore, the substance ever regains a white colour, chlorine must have been purposely furnished from other sources, or the white substance said to result, is some compound of unknown ingredients.

73. The light of the moon is a remarkable example of luminous rays existing without either calorific or chemical rays; the most delicate thermometric arrangements have hitherto failed to show any rise of temperature in the moonshine. A piece of paper, imbued with chloride of silver, may also be exposed to the rays of the full moon, converging from a glass, and it will not exhibit any change; this I proved, by placing such a paper in a

situation where for a whole night the rays of the moon could reach it. And the same observation applies to terrestrial flames. In none of these has the existence of the chemical rays been detected. Chloride of silver, after being exposed for eight hours to the bright flame of an argand lamp, converged by a lens, retained its whiteness. The same effect was witnessed, when the flame of alcohol tinged red by strontian was employed, or the yellow flame produced by chloride of sodium, and the green of Boracic acid; in these cases the periods of exposure did not exceed half an hour.

74. Of the Perihelion motion of matter. Probably the most remarkable effect exhibited by the solar rays, is the motion they produce in media endued with much mobility. For many years it has been known, that camphor exposed in a bottle to the rays of the sun, formed a crystallization on that side of the vessel nearest the luminary; but the action is so slow, and requires such a length of time for its completion, that no successful investigation has been made as to the nature of the forces in operation. Some philosophers have assumed, upon insufficient grounds however, that the crystallization was effected on the most illuminated side, merely because it was the coldest, as we know that vapours are always deposited on that part of a surface whose temperature is the lowest.

75. About three years ago, I published a series of observations on this point, in the Journal of the FranklinInstitute, Vol. XV., p. 156. Having found from some theoretical considerations, that the crystallization of camphor took place in vacuo, with a rapidity convenient for experimental investigation, I was led to make an extended inquiry into the whole matter. The results so obtained, are now given to the public, they appear to me to be so singular and important, and to conceal some secret respecting the physical constitution of the sun's rays, that I cannot doubt they will lead to a rich harvest of discovery.

76. The sun's rays have the power of causing vapours to pass to the perihelion side of vessels, in which they are confined, but, as it would appear, not at all seasons of the year. For example, I have a certain glass fitted up for making these observations, and in this vessel, during the months of December, January, and part of February, 1836—37, a deposit was uniformly made towards the sun; during the months of March, April and part of May next following, although every part of the arrangement remained to all appearance, the same, yet the camphor was deposited on the side furthest from the sun. From May until the present date, the deposit is again towards the sun. It does not appear that any immediate cause can be assigned for this waywardness. Does it exist in the sun's light? or in changes affecting the earth's atmosphere? or in imperceptible changes in the instrument with which the observation is made? as respects the latter, I think a negative answer may be given without any hesitation; but beyond a mere expression of the fact that these anomalous circumstances do occasionally occur, I would not be understood to speak decisively; if periodic changes like this do occur, which is doubtful, they have not been watched for a sufficient length of time, nor have I made sufficient variations in my trials to be able to refer them to any distinct cause. A large bottle containing camphor, which has been deposited therein for more than a year under ordinary atmospheric pressures, has uniformly showed a crystallization towards the light.

77. For making these experiments properly, it is necessary to possess an air pump receiver ground so true as to be able to maintain a vacuum for several hours, or even days. A less perfect jar may be made to answer,

by fastening it down to the pump plate with cap cement, it will however be liable to leak when the cement becomes warm by exposure to the sun. For many of these trials, a barometer tube is sufficient. Those who are provided with a good pump and jars accompanied with their proper transfer plates, will have no difficulty whatever.

78. Upon the plate of the pump, or one of the transferers *a a* Fig. 1, Plate II., place some camphor in a watch glass *c*, supported by a stand; over this place a bell-jar, and exhaust until the difference of level of the syphon guage amounts to half an inch or less, the further the rarifaction is pushed the better; remove the arrangement into the sunshine. In the course of five minutes, if the atmosphere be clear and the sun bright, small crystalline specks will be found on the side nearest to the sun, these continually increase in size, and at the end of two hours, many beautiful stellated crystals, from one-eighth to half an inch in diameter, will be found on that side, but on the other parts of the glass, only a few straggling ones here and there. This appearance, is represented in Fig. 2. Sometimes, as is the case in a result which I keep by me, the whole side next the sun is covered with a lamina of camphor, the other side containing none at all.

79. Or, having made a torricellian vacuum, in a tube upwards of 33 inches long and five-eighths wide, pass into it a piece of camphor, which will rise into the void. This arrangement, like the former, when kept in the dark shows no crystallization, even though so kept for more than four months, but on bringing the vacuum into a beam of the sun, crystallization rapidly goes on, and at the end of a quarter of an hour the appearance is such as represented in Fig. 4. It is not important that the temperature of the sunbeam, or of the atmosphere, should be high; this is an experiment which will succeed at temperatures varying from 120° Fah. to 60° Fah., and probably at much lower degrees, for it is readily performed in the depth of winter.

80. It is in no wise a phenomenon connected with the process of crystallization. Take a jar twelve inches high, and four in diameter, quite clean and dry, place it over a glass of water *b*, fig. 5, and expose it to the sunshine. In this experiment, it is not required that there should be a vacuum within the jar. In the course of an hour or two, there will be a copious dew at *a*, and on further exposure drops of water will trickle down the side of the glass, but on the opposite side not the least cloudiness will be found.

81. Barometers, hung up in such a position that the sun's rays can have access to them, exhibit an analogous appearance on the side nearest the light, being studded with metallic globules.

82. In any of these experiments iodine may be substituted for camphor, provided mercury is not present, nor any other substance on which this material acts; the most advantageous method of using iodine is by heating it in a suitable vessel, and when the vessel is quite full of vapour, presenting it to the sun's ray, deposition goes on, on the perihelion side, as the condensation takes place.

83. Nor is it requisite in obtaining these results, that the material should be either gaseous or vaporous. The rays of light, have the property, as was found by Count Rumford, of decomposing an aqueous solution of chloride of gold; on making this experiment in a test tube one-third of an inch in diameter, as *a* Fig. 6, small spangles of metallic gold will be seen, by reflected light, on the side towards the sun *b*, by transmitted light it appears of a pale green tint, as is the colour of gold leaf. Here we find, that under

certain circumstances, solutions will deposit metallic matter, in obedience to the same laws which cause the crystallization of camphor, and the deposite of aqueous dew.

84. A few pieces of camphor were laid on the plate of an air pump, and a circle of glass two inches in diameter, *a* Fig. 7, was supported on a pedestal in the midst of them, the upper part of the glass being four or five inches above the pump plate; it was then covered with a jar, and exhaustion performed. On exposure to the sun for a suitable length of time, numerous crystals were found on the jar, but none on the circular plate, although it had received the full beams of that luminary. This experiment was made with a view of determining what peculiar condition a glass surface was placed in by exposure to the light; for experimental purposes the rounded form of the glass receivers, being very unsuitable, it was not therefore without surprise, I observed that, however long the plate was continued in the beams of light, no crystallization would ensue. A flat surface, however, being essential to the trains of experiment pursued, trials were repeatedly made, by various changes in the arrangement, to cause a deposition of camphor upon such a crown glass plate; but though in five days I could procure starry crystals upon the bell jar of more than half an inch in diameter, in no instance was a solitary one found on the glass plate.

85. Two circumstances may determine the precipitation of camphor crystals on a surface; 1st, Degradation of temperature; 2d, Increase of pressure. To the former we cannot look for an explanation in the case before us, for there is an actual increase of temperature in every part, and more especially in that side of the vessel which is next to the sun. Why then does this condensation take place on the hottest surface, the side nearest to the sun? we cannot admit, that the rays of heat have any active part in bringing about the phenomenon. On the other hand, they ought rather to exert a contrary effect, antagonizing the powers that solicit the camphor crystals to form, and driving them to the coldest surface. We are therefore reduced to the supposition, that when the light of the sun impinges on a surface of glass, it places that surface in such a condition, that it exerts a pressure on the adjacent medium, immediately followed by a condensation of that medium. The state of the force here spoken of, applies to the glass surface alone; it is not an action between the solar ray and the powers that effect crystallization, seeing that it equally takes place in the deposite of aqueous or mercurial dew, and even of solid gold from a solution of its chloride. In other words, if a ray of the sun be incident on a surface of glass, it develops a force of attraction on that surface.

86. A gaseous medium, having its temperature disturbed at any point, has a current determined in it. In a chamber, such as the bell of an air pump, this current circulates round the walls, ascending on the hot and descending on the cool side; it might be supposed, that to this circumstance was due the fact of no crystals being found on the plate of glass, sect. 84. The condensation cannot however be attributed to this cause; for if so, a lamp, or any other source of heat, would be equally effectual, it will however be hereafter shown, that terrestrial flames tend to remove these depositions from the side nearest to them, and cause them to be accumulated in the colder regions.

87. Beneath a receiver, *a* Fig. 3, a cubical bottle *b*, having flat sides, was placed, and in the bottle a few pieces of camphor, the mouth of the bottle was about half an inch in diameter, and was left open, the pressure of the atmosphere being reduced to $1\frac{1}{2}$ inches of mercury. Temperature of the

ray 57° Fah. On examination after the lapse of one hour and twenty-five minutes, no crystals whatever could be found on the receiver, and but a few sparsely scattered on the sides of the cubical phial. Now there can be no doubt that the whole receiver was full of camphor vapour, and it does not appear, that any reason can be assigned for the anomaly of its non-crystallization.

88. Will artificial light produce analogous results? To ascertain this, I took a glass globe about one inch and a half in diameter, with a neck four inches long, fitted it with a stop-cock, and introduced within it a drop of water. The vapour of this water exhibited extreme mobility; the light from the clouds caused its immediate deposition. A further advantage was gained by the use of this apparatus, for by heating the globe uniformly, until all the moisture on its surface was vapourized, and then allowing it to cool, the particles of water readily obey the forces that solicit them. This glass globe, supported vertically on an appropriate stand *a*, Fig. 8, plate II., was placed at a distance of nine or ten inches from a brightly burning argand lamp A; to protect it from accidental currents of air, and from irregularities of radiation from other sources, the whole arrangement was covered by a bell *b c*, open at both ends, and about fifteen inches high. It appeared at first that a thin dew lined the inside of the whole globe, instead of being confined to one part, but after a certain space of time, the heat which passed from the lamp through the protecting glass, disturbed the results, the dew being driven to the coldest parts. To get rid of the effects of this heat, at a distance of about three feet from the lamp A, Fig. 9, a double convex glass lens *c*, 2½ inches in diameter, was placed, which brought the rays to a focus at a distance of five or six feet, where stood the glass globe *a*, covered with its protecting jar. The globe had been previously slightly warmed, so as to expel all the dew from its surface, and give it an uniform temperature; in several trials it was found, that there were no evidences that the bright flame of an argand lamp exerted any force soliciting the vapour of water to move towards one part of the glass, rather than another.

89. I took the arrangement of section 80, and shut it up in a dark closet, having previously made the jar perfectly clean and dry; it remained there for several days, that it might be found whether those little irregularities of temperature which occur in such confined chambers, would cause this dew to pass to one side of the glass rather than another; it did not appear that such was the case, for the glass was as free from moisture when taken out, as when shut up. And now, this arrangement being placed in the window, where the sun was brightly shining, exhibited on its perihelion surface in the course of three and a half minutes, a pearly dew; and in six minutes drops of water were trickling down that side.

90. But it is not essential to the success of this last experiment, that the solar ray itself should impinge on the vessel. The temperature in the shade being 94° Fah., I placed the receiver with its cup of water in a window having a northern exposure, and found that the dew readily made its appearance on that side which was towards the light.

91. It has been suggested by some who have seen these experiments performed, that when a glass vessel is exposed to the sun, that part of the glass which is nearest to him, may actually be the *coldest*; such an opinion it is evident rests on no sufficient grounds; for the sake however of those who see force in this objection, the following experiment was made. A jar *a g*, Fig. 10, was taken, of such dimensions that it could receive the differential

thermometer *c d b*, the balls of which *b* and *c*, touched the opposite sides, and in the dark the liquid stood at zero, but on bringing it into the sunshine, if the side *a* was exposed, then the ball *c* was warmest, and if the side *g* then the ball *b* was warmest, as was indicated by the motion of the liquid. Hence we know, that in all cases where crystals of camphor, dew of water, &c. are deposited on the side next the sun, they are so deposited in spite of an energetic force, which tends to remove them.

92. Light which has suffered reflexion at certain angles, appears to have undergone a remarkable modification, being no longer able to put the glass into such a condition that it can cause motion towards the sun. It is not to be inferred that any connexion is here traced between this disturbance of the condition of light, and the change impressed on it by polarization. A beam of the sun falling on a plate of glass, and being reflected at an angle of 45°, may be intercepted by any of the arrangements of sections 78, 79, as by the barometer tube. It will be found that the crystallization proceeds with considerable rapidity, not however on the perihelion side of the vessel, but on the opposite side. It is probable that this result is not dependent on the polarization of light, inasmuch as it takes place equally well at all the angles, less and greater than the maximum angle of polarization of glass. A ray of the sun cannot be made to disappear entirely, as is well known, by any disposition whatever of two reflecting glass plates, though the pale light shed by the clouds, may be very nearly brought to that condition. But light, even that of the sun, having once undergone reflexion, has received some determinate impress, which disables it entirely from causing camphor to crystallize on the perihelion side of vessels.

93. Another very remarkable phenomenon, is exhibited by the following arrangement. Take a receiver *a*, Fig. 11, twelve or fifteen inches high, and three or four in diameter, place it as usual upon the transfer plate, with its proper charge of camphor *c*. Then cover it with a tin cylinder *e f* of sufficient dimensions, to the end that all the light may be shut out, except at one point *g* where there is a hole, half or three-quarters of an inch in diameter. Under favourable circumstances, as a serene sky and bright sun, let the arrangement be exposed so that a column of light may pass through the aperture *g*, into the glass, it may or it may not finally fall on the camphor at *c*. It would of course be expected, that a collection of crystals would form on the inner surface of the glass, corresponding to the aperture *g*. But on trial it is not so; for however bright the sun may shine, or however favourable other circumstances may be, not a solitary crystal will make its appearance, either there or on any other part of the vessel, provided its temperature has been pretty uniform. On an exceedingly calm and serene day in July, 1835, when every circumstance seemed propitious, I made trial of this matter, and because the jar that I was using was not ground sufficiently true to fit the transfer plate accurately, it had been fixed thereon with common cap cement, and on exposure to the sun, the temperature of the whole arrangement rose so high, that the cement was in almost a semifluid condition; it was one of those days when the eye cannot behold the sky, or look on the ground, without pain, yet not one crystal could be made to appear opposite to the whole. But on taking off the metallic screen, and exposing the jar, in a little more than a minute, small specks were observable on the glass, and in a quarter of an hour, its perihelion side was densely coated with crystals. How are we to explain this? Do the edges of the aperture *g* impress any change on the passing light? Or is the glass surface placed in such a condition, that it can no longer solicit

the deposit of crystals, we shall see hereafter that there are circumstances yet more remarkable, which put us in possession of an explanation.

94. For the proper understanding of the rationale of these experiments, it is required to know, whether it be essential that the solar ray should impinge on the camphor or not; or whether the action is spent on the vapour only. A tube was therefore taken of suitable dimensions, in the lower part of which a fragment of camphor was deposited, and screened as much as possible from the rays of the sun, whilst the upper part of the tube was freely exposed. Crystals formed without difficulty, at a distance of three or four inches, or even a foot, from the camphor, but there appeared to be a limit beyond which they did not readily pass. A tube four feet six inches long, and two inches in diameter, being exhausted, did not show on its exposed end any appearance of crystallization. Near the camphor the deposit was pretty copious, but in advancing from it the crystals were more sparsely scattered, until towards the upper extremity none could be seen. Now the maximum quantity of vapour that can exist in a void, or among other gases, provided the mixture be in æquilibris, depends on the lowness of the temperature of any one part of the vessel, and hence a long tube one of whose extremities is kept cold, does not exhibit these configurations readily, because the quantity of vapour in it is small, owing to the coldness of one part of the void space. It is not necessary, therefore, that the sun should shine *on* the camphor, the effect of the rays taking place entirely on the vapour filling the void.

95. I now come to develop a singular action which certain bodies exert over this process. Take a receiver, able to maintain a vacuum for some time, and having cut out a ring *a*, Fig. 12, Plate II., of tin foil, an inch and a half or thereabouts in internal diameter, and half an inch wide, paste it upon the receiver as at *a*, Fig. 16, moreover, accommodate the receiver with its camphor as usual, and having exhausted, expose it to the direct rays of light, so that the ring *a* shall be on the perihelion side. In the course of a short time that surface will be found studded in various directions with crystals, as is to be expected; but it will be found that none of these crystals trespass within a certain distance of the ring, and that not one is to be seen within the circle circumscribed by it. The ring, therefore, exerts a kind of protecting action on the glass, forbidding the deposition of crystals within certain limits; such a result is depicted in Fig. 13.

96. This action of a ring, formed of good conducting materials, might be supposed to arise either from its adding something to the surface of the glass, or taking something away from the glass with which it is in contact. Or, on the other hand, it might be imputed to some change impressed on the ray of light. Take therefore a ring *a*, Fig. 14, and place it *before* the receiver *b*, at a distance of half an inch, the ring being of the same dimensions as in the last experiment, it will be discovered that although the ring does not *touch* the glass, it still protects it, no crystals coming within a certain distance of the regions overshadowed by the metal. Nay, even at a distance from the line of shadow, not a crystal is to be seen, nor are any visible in the illuminated centre.

97. Even after crystals have been formed on the surface of the jar, if it be placed in the sunshine with a ring before it, as in the foregoing experiments, the ring will be found not only to exert a protection on the glass, hindering any further deposit, but will even *remove the crystals that are there.*

98. This is indeed a remarkable circumstance; a part of the perihelion

surface is shaded from the sun, and thereby rendered cooler, yet the crystals deposit themselves on the hottest surface, and avoid that where it is cold. I know of none of the commonly received doctrines, that will give the shadow of an explanation of the matter. We see, however, how it happens that in the experiment of admitting a column of light through a hole in a screen, no crystalline deposite was effected, the protecting agency of the metal, whatever its power might be due to, seemed to hinder it.

99. To give the particulars of one of these experiments. On the 11th of July, I prepared an arrangement, such as the foregoing, the thermometers in the shade were at 76° Fah., and in the sun at 99° Fah., distance of the ring from the jar half an inch, its natural diameter .75, width half an inch. After proper exposure, the jar was examined, there were no crystals on that part opposite the central opening of the ring, and the nearest crystal to the natural border was $\frac{6}{10}$ inch distant from where the shadow was projected on the glass.

100. Vapour of water exhibits similar phenomena, a thin lamina of tin foil in the form of a cross, a ring, or any other shape, effectually prevents the deposit of water near it.

101. Instead of placing the ring outside of the glass, now let it be placed on the inside, as at *a*, Fig. 15, so that it may be within one eighth of an inch of the surface. When the crystals have fully formed, it will be discovered, that the ring has exerted the same kind of protecting agency that it did when on the outside of the glass.

102. Hitherto, a class of bodies has been tried, as protectors, which are without exception good conductors of electricity, such as the metals. Certain indications led me to make trial of resinous matters, which are non-conductors of electricity. Having made the region about *a* fig. 16, of the air-pump jar, very warm, over a spirit lamp, a ring of rosin was spread on it, about the same size as the ring of tin foil, which had been formerly there. This ring of rosin was transparent, admitting the light to pass it readily, and at a certain distance appeared of a fair amber colour. Having arranged the jar as usual and exposed it to the sun, after a certain length of time well marked crystals were deposited on the perihelion side, on which the rosin was; these crystals not only came up to the verge of the rosin and filled also the inner circle, but were found on the rosin itself.

103. Metallic plates of various shapes, and under various circumstances were exposed with a view of causing condensation upon them; it was not found possible however either to cause the formation of aqueous dew, or crystalline deposit, except when their temperature was below that of the medium in which they were exposed.

104. At this stage of the inquiry, it becomes important to know, whether along with the rays of light, of heat, and of chemical action, there are not also rays of radiant electricity, emitted by the sun. Almost all operations which disturb the equilibria of light and heat, disturb too that of electricity, and it is well known that, upon this fact, Dr. Hare founds the explanation of the action of certain voltaic arrangements, especially the calorimoter; an explanation, the correctness of which, later researches make more probable. If light, heat and electricity are set in motion by the force of chemical action, and are often found co-existing, there is nothing improbable in meeting them together in the case before us. It is very true, that as yet we have not met with any example of electricity, under what we understand as a radiant form, but that it consists of undulations of an elastic medium, like the undulations of light and heat, is not to be doubted. The experi-

ments of Nobili give proof of an interference, analogous to the interference of the rays of light, which has served so well to refer the motions of that fluid to the undulations of an elastic medium; the analogies of light and heat are every where kept up, and we look with confidence that they will be extended hereafter to electricity.

105. "Quelle imposante découverte ne serait-ce pas, si l'on parvenait á déduire de la lumiére rayonnante, les propriétés par lesquelles les èlectricités neutralizées se signalent." (Berzelius T. de Ch. T. 1, p. 45.) The tendency of the experiments here communicated, is to show that certain substances, conductors of electricity, have the faculty of depriving glass of that power by which it causes the condensation of vapours upon it when exposed to the sun; that deposition will not take place on metallic surfaces, but that certain vitreous and resinous bodies, interfere in no manner with the process. The inference appears inevitable, that electricity brought into play in some unusual manner, is the cause of the phenomenon.

106. By the action of the solar ray, electricity of high tension *can* be developed. A copper electrical condenser was taken, the plates of which were about one-fortieth of an inch apart, and six inches in diameter; there was nothing more in their construction than is met with in the usual arrangement. Another condenser was also provided, which was connected with a gold leaf electrometer, the plates being one inch in diameter, and separated from each other by a very thin coat of gum lac varnish. Trials were repeatedly made to discover whether the apparatus was trustworthy. It is a common complaint against instruments intended to indicate low charges of electricity, that they furnish evidence of an accumulation when none has been communicated; it is necessary therefore to examine each instrument by strict tests, to be certain that this charge cannot be preferred against it. Having obtained this preliminary evidence in a satisfactory manner, and having decided the effectual goodness of the instruments in other particulars, the following trial was made. The six inch condenser was exposed to the sun-beam for one hour, on a clear bright day; the charged plate was then parted, and applied to the one inch condenser; the plates of this being parted, a small but perfectly distinct electric action was obtained. This experiment is not however devoid of sources of error, as from the friction occasioned by touching the plate of one condenser with the plate of the other, or the heating action of the ray, which might cause currents of air to brush over it, but it was found, by purposely rubbing one plate of the condenser on the other, that no charge of electricity could be produced, even if the friction were continued during some time; and on maintaining the temperature of the condenser at the same point to which it was brought by the sunbeam, in order to produce like currents of air, no divergence whatever of the gold leaves was produced.

107. When the tension of electricity is high, one of the most delicate methods of detecting its presence, is by the light it emits in vacuo; the excitation caused by the tremulous motion of a column of mercury in a barometer tube, is rendered visible by the bright light it gives out, when no other method could discover it. On this principle, attempts were made to detect electrical action in the sunbeam, by exposing metallic plates of large dimensions to the ray, and causing any electricity they might gather, to give out light in a vacuum; these trials did not prove satisfactory.

108. It has been stated in another part of these papers, that the cloud which rises from phosphorus when slowly oxydating, is endowed with great mobility; for certain purposes it makes a very good electroscope. When a

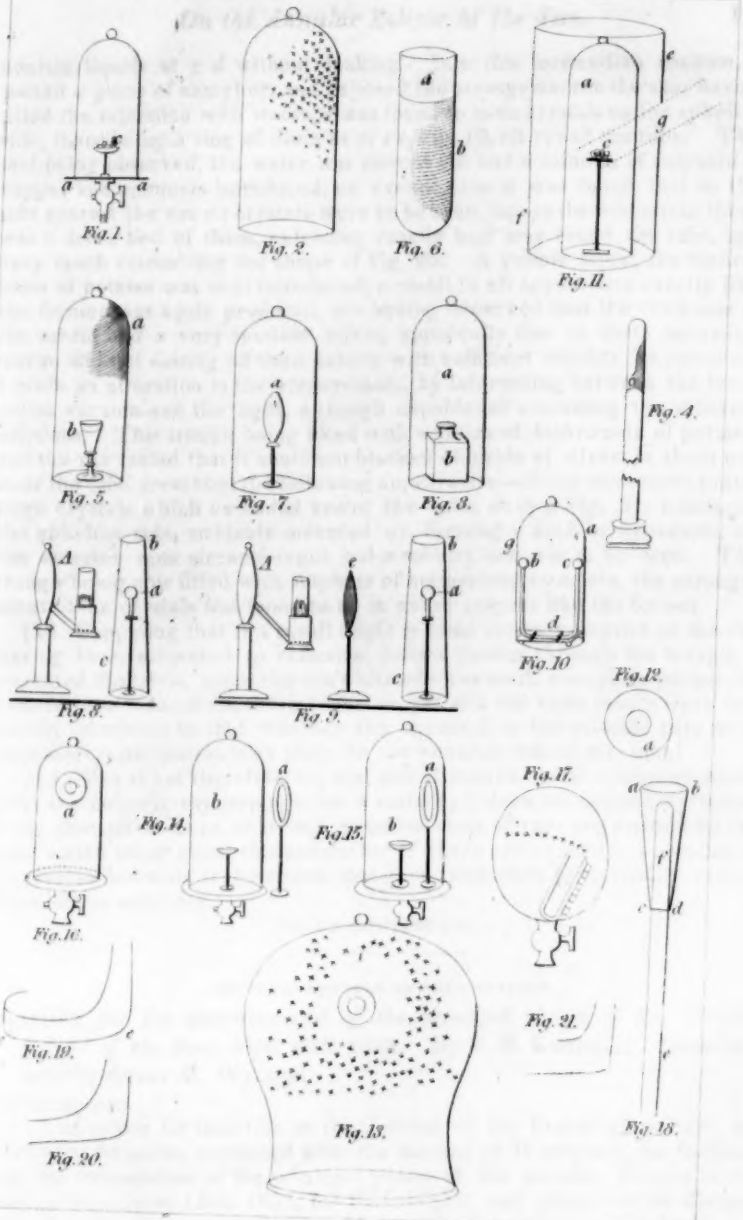
piece of this substance is shielded from the air by a bell jar, and not exposed to disturbing action of any kind, a fine sheet of vapour rises vertically upwards. If at a distance of several feet, an excited stick of wax be presented, the vapour curls from its path, and leans over to the side of the glass adjacent to the cause of the disturbance. If such a jar be exposed to the sun, a like disturbance is exhibited; as soon as the rays fall on it, it seems as though they caused each particle to repel its fellows, the straight column which before passed to the top of the jar, separates into confused masses which pass forward to the perihelion side.

109. No direct proof existing that rays of electricity are emitted by the sun, and as it does not fall within my limit to discuss their hypothetical action, it may be sufficient to give the proof, that if the surface be admitted to be electrified, these deposits should take place. If a receiver be taken clean, dry, and exhausted, and on any part of its interior surface a glass rod be made to pass, the line which it describes will be stellated with camphor crystals, if any of that odoriferous substance be present. This curious fact was first observed in the case of an exhausted vessel, which had a small syphon gauge shut up in it, the extremity of which rested against the glass; by accident the gauge was moved half round the glass, and in a short time after a line of crystals was observed coinciding with the line of motion; it was found possible afterwards to repeat this result at pleasure; the appearances were such as are represented in Fig. 17., Plate II.

110. Upon the hypothesis here assumed, the deposit of crystals becomes a phenomenon analogous to the curious configurations described by Lichtenburg, when powders are dusted on the surface of an electrified plate; so close is the resemblance, that one who sees crystallization produced by the sun for the first time, would be led almost involuntarily to refer them to the same cause; suppose it granted, that when light falls on any surface that surface is electrified, it will exert an attraction on any particle within its vicinity; but, if a conducting substance be placed in contact with the surface, not only will it hinder deposit on the place which it occupies, but also it will rob the glass around it for some distance; here we find an explanation of the action of a tin foil ring. Again, if that conducting substance be so placed as to cast its shadow on the glass, no deposit should take place on that shadow, nor for a certain distance around it, because the electricity of the adjacent parts would pass towards the unelectrified spaces, thus conferring by a surface conduction, a low charge to all the shaded parts.

111. We meet, however, if we pass beyond these simple explanations, with so many difficulties, that we are not encouraged to seek further confirmation of this hypothesis; there are some facts which prove almost demonstratively, that electricity is not the agent in question. If, instead of a ring of rosin we make use of a ring of sealing wax, or a ring of pitch, these, though they are non-conductors, do not fail to protect; the action of a metallic ring when placed inside of a jar, cannot, so far as I know, receive any explanation, especially if we are to admit the non-conducting power of a space filled with camphor vapour only. It is plain and obvious, that transparency and opacity have nothing to do with it; glass and rosin, it is true, do not protect; but oil, which is equally transparent, protects as powerfully as a metal.

112. Are we to refer this singular action, to the rays of light, to the rays of heat, or to the chemical rays? By the action of absorbent media, attempts have been made to satisfy this question. A barometer tube *f d e*, Fig. 18, had a conical tube fixed on its outside, so that the interstice could



$$+ \left[0.04096\right] \cos. l \cos. (\wedge + 211° 16'5)$$

[illegible] tube fixed on its outside, so that the interstice could

contain liquids at *c d* without leaking. Into this torricellian vacuum, I passed a piece of camphor, and exposed the arrangement to the sun; having filled the interstice with water, it was found to have crystals on the aphelion side, there being a ring of them as at *e e*, Fig. 19, all round the tube. This fact being observed, the water was poured out and a solution of sulphate of copper and ammonia introduced; on examination it was found, that on the side nearest the sun no crystals were to be seen, but on the other side there was a dense bed of them, extending exactly half way round the tube, and very much resembling the shape of Fig. 20. A yellow liquid, the bichromate of potassa was next introduced, a result to all appearance exactly like the former was again produced, but having observed that the thickness of the media had a very sensible effect, apparently due to their becoming warm, and not casting off their caloric with sufficient rapidity by radiation, I made an alteration in the arrangement, by interposing between the torricelian vacuum and the light, a trough capable of containing the different solutions. This trough being filled with solution of bichromate of potassa, and the ray tested that it could not blacken chloride of silver; in about one hour the tube presented the following appearance:—there were some pretty large crystals which extended round the tube, as at *a* Fig. 21, which, on the aphelion side, suddenly mounted up, forming a kind of hyperbola, on the anterior semi circumference not a solitary one was to be seen. The trough being now filled with sulphate of copper and ammonia, the arrangement of the crystals was found to be in every respect like the former.

113. Supposing that this result might in some measure depend on the ray having been subjected to reflexion, before passing through the trough, I repeated the trials, when the sun's altitude was small enough to permit the rays to pass without requiring reflexion, yet still the same results were uniformly obtained; so that whether the chemical or the calorific rays were stopped, crystallization took place on the aphelion side of the tube.

114. May it not therefore be, that this attractive force originates wherever the colorific ray impinges on a surface; it does not necessarily follow from the phenomena, that any peculiar class of rays are emitted by the sun, which bring about this action, but if there are such, it is a question of interest to find what is the reason that good conductors of electricity, render their action nugatory.

(TO BE CONTINUED.)

TO THE COMMITTEE ON PUBLICATIONS.

Formulæ for the announcement of the principal phases of the Annular Eclipse of the Sun, Sept. 18th, 1838. By E. O. KENDALL. *Communicated by* SEARS C. WALKER.

GENTLEMEN:

I send you for insertion in the Journal of the Franklin Institute, the following formulæ, computed after the method of Woolhouse, for facilitating the computation of the principal phases of the annular Eclipse of the Sun of September 18th, 1838, for Philadelphia and places not far distant. The part which relates to limits of latitude will be found particularly useful in enabling observers to select convenient places for observation.

$$\begin{aligned}\cos.\ \varphi_{,,} = &+ 1.43404 \\ &- [0.14000] \sin. l \\ &+ [0.04096] \cos. l \cos. (\lambda + 211^\circ\ 16'5)\end{aligned}$$

$$\begin{aligned}
\text{cos. } \alpha &= +\ 40.98359 \\
&\quad -\ [1.57169]\ \text{sin. } l \\
&\quad +\ [1.40297]\ \text{cos. } l\ \text{cos. } (\lambda + 230^\circ\ 45.'5)
\end{aligned}$$

$$\begin{aligned}
\text{cos. } \alpha'' &= +\ 1.59753 \\
&\quad -\ [0.18039]\ \text{sin. } l \\
&\quad +\ [9.94995]\ \text{cos. } l\ \text{cos. } (\lambda + 248^\circ\ 12.'5)
\end{aligned}$$

$$\begin{aligned}
t_{,,} &= +\ 9^h\ 26^m\ 52^s.3 \\
&\quad -\ [3.70767]\ \text{sin. } \alpha_{,,} \\
&\quad -\ [3.74730]\ \text{sin. } l \\
&\quad -\ [3.84836]\ \text{cos. } l\ \text{cos, } (\lambda + 216^\circ\ 42.'6)
\end{aligned}$$

$$\begin{aligned}
t_{,} &= +\ 9^h\ 0^m\ 55^s.4 \\
&\quad -\ [2.25147]\ \text{sin.} \\
&\quad -\ [3.65312]\ \text{sin. } l \\
&\quad -\ [3.82359]\ \text{cos. } l\ \text{cos. } (\lambda + 235^\circ\ 48.'9)
\end{aligned}$$

$$\begin{aligned}
t &= +\ 9^h\ 0^m\ 55^s.4 \\
&\quad -\ [-\infty\ ] \\
&\quad -\ [3.65312]\ \text{sin. } l \\
&\quad -\ [3.82359]\ \text{cos. } l\ \text{cos. } (\lambda + 235^\circ\ 48.'9)
\end{aligned}$$

$$\begin{aligned}
t' &= +\ 9^h\ 0^m\ 55^s.4 \\
&\quad +\ [2.25147]\ \text{sin.} \\
&\quad -\ [3.65312]\ \text{sin. } l \\
&\quad -\ [3.82359]\ \text{cos. } l\ \text{cos. } (\lambda + 235^\circ\ 48.'9)
\end{aligned}$$

$$\begin{aligned}
t'' &= +\ 8^h\ 56^m\ 7.^s9 \\
&\quad +\ [3.61381]\ \text{sin. } \alpha'' \\
&\quad -\ [3.56251]\ \text{sin. } l \\
&\quad -\ [3.79452]\ \text{cos. } l\ \text{cos. } (\lambda + 252^\circ\ 56.'2)
\end{aligned}$$

$$\begin{aligned}
\text{cos. } (N + l_{,}) &= -\ [0.22011]\ \text{sec. } (\lambda + 230^\circ\ 45.'5)\ \text{cos. N} \\
\text{cos. } (N + l^\circ) &= -\ [0.20964]\ \text{sec. } (\lambda + 230^\circ\ 45.'5)\ \text{cos. N} \\
\text{cos. } (N + l') &= -\ [0.19891]\ \text{sec. } (\lambda + 230^\circ\ 45.'5)\ \text{cos. N}
\end{aligned}$$

$$\begin{aligned}
\text{tan. N} &= +\ [0.16872]\ \text{sec. } (\lambda + 230^\circ\ 45.'5) \\
\text{L} &= +\ [1.85612]\ \text{cos. } \alpha
\end{aligned}$$

Where

$t_{,,}$ = Greenwich mean time of beginning.
$t_{,}$ = " " formation of the Ring.
t = " " nearest approach of Centres.
t' = " " rupture of the Ring.
t'' = " " end.
λ = Longitude from Greenwich + East, — West.
l = Geocentric latitude of place of observation.
$l_{,}$ = " " Northern limit of the annular eclipse for longitude λ.
l° = Geocentric latitude of central eclipse for longitude λ.
l' = " " Southern limit of the annular eclipse for longitude λ.

L = least distance of centres in seconds of arc of great circle.

l, l° and l' may be reduced to geographical latitudes by adding the angle of the vertical, which is 11′ nearly.

These equations have been computed for Philadelphia, for which place only they are rigorously correct. The sum of the Semi-diameters has been diminished 5″ for irradiation.

If we assume 6″, as the probable error in the difference of the sun's and moon's declination taken from the Nautical Almanac, we shall have 30 geographical miles, nearly, as the probable error in the limits of latitude resulting from the above formulæ.

The following table contains the times of the principal phases, correct for Philadelphia, and approximate for several other places, with the limits for the annular phase expressed in geographical latitudes.

	Baltimore.	Harrisburg.	Havertord.
Geographical latitude,	39° 17′ 13″	40° 16′	40° 1′ 12″
Longitude from Greenwich,	76 37 50	76 50	75 19 0
Beginning, mean time,	3h 6m 36s.2	3h 3m 24s.0	3h 11m 35s.5
Formation of Ring, mean time,	4 24 44. 0	4 21 54. 2	4 29 33. 3
Nearest approach, "	4 27 38. 8	4 24 36. 7	4 31 59. 6
Least distance of centres,	14″4	29.″7	41.″1
Rupture of the Ring, mean time,	4h 30m 33s.6	4h 27m 19s.2	4h 34m 25s.9
End, "	5 40 4. 4	5 37 16. 8	5 43 56. 9
N. limit of ann. phase for this long	42° 43′ 12″	42° 51′ 42″	41° 52′ 12″
Lat. of central eclipse "	38 30 42	38 37 48	37 46 42
S. limit of ann. phase "	35 0 18	35 6 54	34 20 54

	New York.	Philadelphia.	Washington.
Geographical latitude,	40° 42′ 40″	39° 56′ 59″	38° 52′ 54″
Longitude from Greenwich,	74 1 8	75 10 59	77 1 48
Beginning, mean time,	31h 6m 34s.1	3h 12m 25s.4	3h 5m 28s.4
Formation of the Ring, mean time,	4 35 5. 3	4 30 18. 7	4 23 43. 7
Nearest approach, "	4 36 17. 9	4 32 44. 7	4 26 42. 0
Least distance of Centres,	65.″6	41.″3	2.″5
Rupture of the Ring, mean time,	4h 37m 30s.5	4h 35m 10s.7	4h 29m 40.s3
End, "	5 47 47. 7	5 44 38. 0	5 39 14. 5
N. limit of ann. phase for this long.	41° 5′ 24″	41° 47′ 6″	42° 59′ 24″
Lat. of Central Eclipse, "	37 6 30	37 42 24	38 44 24
S. limit of ann. phase, "	33 45 6	34 16 0	35 12 48

Franklin Institute.

Quarterly Meeting.

The Fifty-fourth Quarterly Meeting of the Institute was held at their Hall on Thursday, July 20th, 1837.

Mr. Joseph M. Trueman, was called to the Chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations of Books were received from:

The Hon. Secretary of War U. S., Washington City, D. C.—the Institute of Civil Engineers—the Royal Society—Zoological Society—Society for the encouragement of Arts, Manufactures and Commerce; James D. Forbes, Esqr., and Petty Vaughan, Esq., London; David Stevenson, Esq.,

Edinburgh; the Royal Irish Academy, Dublin; Prof. Alex. D. Bache, Wm. Duane, Jr. Esq., Peter A. Brown, Esq., Messrs. Carey & Hart, and Mr. John Thomason, of Philadelphia.

Donations to the Cabinets were received from Franklin Peale, Esq., of Philadelphia, Abraham Morrison, Esq., of Cambria Co., Penna., and Capt. Jeffries of the Steamboat Ohio.

The Actuary laid on the tables the periodicals received in exchange for the Journal of the Institute since the last meeting.

The quarterly report of the Board of Managers, was read and accepted.

On motion, the resolution contained in the report of the Board of Managers and by them recommended, relative to Meteorology was adopted.

The Treasurer presented his quarterly report of the finances of the Institute, which was read and approved.

On motion, the reports were referred for publication.

[Extract from the Minutes.]

JOSEPH M. TRUMAN, *Chairman.*

ISAAC B. GARRIGUES, *Rec. Sec.*

Fifty-fourth Quarterly Report of the Board of Managers of the Franklin Institute.

At the time of the last quarterly meeting, the public operations of the Institute in the interesting department of Instruction were just brought to a close for the season. Since that time the summer recess has continued as usual, and the Committee on Instruction have been giving consideration to arrangements for opening the approaching session with renewed means of usefulness.

In its numerous other departments, the silent labours of the Institute have been attended with a sufficient measure of success to encourage us to new and increased exertions: among these the Journal continues to claim and receive primary consideration and care; the number just issued completes the 19th volume, and it is believed will be found to contain an amount of valuable and interesting original and selected matter, fully sufficient to maintain its standing among scientific periodicals. Owing to circumstances not within the control of the Committee on Publications, the last few numbers have been delayed beyond the usual time; but it is hoped that the publication of the future numbers may be accelerated so as to restore their issue to the proper periods.

The accompanying report from the Committee on Sciences and the Arts, affords evidence of unimpaired activity and usefulness on their part, and of the high estimation in which their decisions are held as well by government as by individuals.

In accordance with the regulation adopted at their foundation, the monthly conversation meetings will be suspended during the months of July and August; but it is believed that the members are now entering into the spirit of these meetings with a zeal that will ensure to them, when they shall be renewed in the autumn, a continuance of the interest by which they have been characterised during the past quarter.

At the request of a number of the members both of the Institute and of the Mechanics' and Tradesmen's Exchange Co. arrangements have recently been made to open the reading room of the Institute daily (Sundays excepted) from 10 o'clock A. M., until 2 P. M., so as to provide for our members

a convenient exchange for the transaction of business and the deposit of letters.

The superintendence of the Exchange room has been referred to a standing committee of eight members, consisting of Messrs. Jno. S. Warner, John Struthers, Isaac B. Garrigues, Andrew M. Eastwick, John Gilder, Joseph M. Truman, Jesse Williamson, and Briton Corlies.

On report of this Committee, the following rules have been adopted for the regulation of the Exchange:

1st. The hour of high change shall be 11½ o'clock, A. M.

2d. Members shall have the privilege of introducing to the Exchange room strangers, who shall then have free access to the room during one month. All visiters must be presented to the Actuary, and their names, occupations, and residences be entered in a book appropriated for the purpose, with the signature of the member by whom they are introduced.

3d. Any member mutilating the books, newspapers, or other articles in the room, or removing them from the room without permission from the proper authority, shall be liable to such penalty as the Board of Managers may exact.

4th. No member, whose annual contribution for the current year is unpaid shall be entitled to the privileges of the Exchange room.

The Board have delegated to the Committee on the new Hall the duty of carrying into effect the resolutions adopted at the late special meeting of the Society. That Committee are proceeding in the performance of the duty assigned them and the measure thus far promises the desired success. The certificates of loan in small amounts have been engraved on steel and printed in a style at once creditable to good taste, and secure from the danger of spurious imitations. These certificates may be confidently recommended to the members of the Institute and the public, as possessing a security not surpassed by the issues of any other institution.

Connected with this subject, and in order to provide the funds for the redemption of the certificates, the Board has authorized the Actuary to receive subscriptions of five dollars, and weekly deposits of sums from one dollar upwards, to accumulate at interest until the same amounts to twenty-five dollars, when a transferable certificate in the Six per cent. Loan, redeemable in 1856, will be issued to the depositor. It is believed that there are many members of the Institute who have hitherto been deterred from subscribing to the Loan by the uncertainty of the time when they might be called on to pay the instalments, and the plan now proposed will put it in the power of every one to contribute to the erection of a suitable building for the accommodation of the Institute, and at the same time secure a good Interest from his savings in a perfectly safe investment. The resolution of the Managers on this subject is herewith communicated and the Board request that an extensive circulation and recommendation of the plan be given by the members.

Resolved, That in order to provide permanently for the redemption of the evidences of debt issued pursuant to the authority given by the special meeting of the Institute, held July 9th, 1837, and to meet the payment to the Grand Lodge hereafter to fall due, the Actuary be authorized to receive subscriptions to the Six per cent. Loan of the Institute, redeemable in 1856, on the following plan—the first payment on the subscription to be five dollars and the subscribers to make weekly payments thereafter of one dollar or upwards, to accumulate at interest until the same amount to twenty-five dollars, when the Treasurer shall issue, to each subscriber who

has that amount to his credit, a transferable certificate of the said Six per cent. Loan.

An application has recently been made to the Board of Managers by the Meteorologist of the Joint Committee of the American Philosophical Society and of the Franklin Institute, asking some action on the part of the Institute, for the purpose of bringing the subject of Meteorology before Congress.

The Board therefore recommend to the Institute the adoption of the following preamble and resolution:

Whereas, a considerable number of members of this Institute, in conjunction with members of the Philosophical Society, have recently devoted much time to the observation of the phenomena accompanying the various conditions of the atmosphere, with a view to ascertain the general laws by which the changes of weather are governed; and the belief is confidently entertained, that a continuance of these observations, and their extension over the widely spread territory of the United States, will enable us to determine many general facts of a highly important and useful character. Therefore,

Resolved, That the Joint Committee of the American Philosophical Society and the Franklin Institute be and are hereby authorized, on the part of this Institute, to memorialize Congress for the purpose of obtaining national aid in furtherance of this interesting object.

Monthly Conversation Meeting.

The Tenth and last Monthly Conversation Meeting of the season was held at the Hall of the Institute, on Thursday, June 22d, 1837.

The meeting was numerously attended, and the number of interesting objects was unusually large; among them was a specimen of caoutchoucine procured from the works of Messrs. Enderby by our fellow member Prof. A. D. Bache. Professor Hare offered some interesting remarks upon this curious liquid, he describes it as an extremely light and volatile substance, highly inflammable, and producing intense cold by its rapid evaporation. The vapour possesses great specific gravity and can be poured like water from one vessel into another. This experiment was shown by the professor, who at the same time cautioned members not to repeat it without great care, as the inflammable and explosive nature of the vapour renders it very dangerous to handle. It is obtained by distillation of caoutchouc and is used as a solvent of caoutchouc in the preparation of water proof cordage.

Dr. J. K. Mitchell presented a small model of a bedstead admirably calculated to promote the ease of invalids.

Mr. S. D. Breed exhibited a large gum elastic hose intended as a substitute for a slide in fitting a gas chandelier.

An easy chair, invented by ——— Clark, of New York, ingeniously contrived to encourage indolence, was exhibited by Mr. T. Roberts.

This piece of furniture comprises, under an elegant exterior, all the properties of an arm chair with or without rockers, a cradle capable of extension to correspond with the increasing dimensions of the occupant, a bed in which the back and head may be readily inclined at any desired angle, and the feet or either of them elevated, depressed or extended at pleasure; in addition to which it could be instantly converted into a four wheeled carriage, for the transportation of its *passenger* from place to place.

A Polygraph, or machine for writing several letters simultaneously, was

exhibited and described by Mr. Franklin Peale, who presented the instrument to the Institute to be deposited in their Cabinet, Mr. Peale stated that it was of a small size intended for use during a journey, with two pens, but that others of larger size for two or more pens, had been in ordinary use for many years, that it was the joint invention of John J. Hawkins at present of London, and the late Charles Wilson Peale, by whom it was patented about the year 1805, and that his father always used it from that time during the remainder of his life, a period of about twenty years, the venerable Thomas Jefferson having also used it during the same length of time.

Mr. Peale also exhibited an improved metallic pen, from the same prolific source in mechanics, Mr. J. J. Hawkins of London, which appears to have combined in this instrument, all that has hitherto been found deficient in its use.

The point or nib was represented to be made of a native alloy of Osmium and Iridium, possessing a degree of hardness equal to the ruby, soldered to a plate of Palladium, a metal remarkable for its elasticity, forming the body of the pen, these metals being insoluble in the acids of inks, and the point from its extreme hardness, not being liable to wear, give to these pens an unknown degree of durability, which has been tested by four years constant use without any perceptible change.

A Portrait Lathe, made for the Mint of the United States, was also exhibited by Mr. Peale, an instrument of highly perfected construction by "Contamin" of Paris, intended to copy and reduce medals or other designs in relief, upon steel, ivory, or other material, with specimens of the work executed upon it, shewing a faithfulness of copy that was truly admirable. Whilst describing this lathe Mr. Peale took occasion to present to the notice of the meeting, a beautiful miniature bust in ivory of Franklin, the property of Mr. Joseph Saxton, executed upon a lathe invented by John J. Hawkins, by Chevendon of London, and stated at the same time that this instrument was now brought to such perfection, by the latter gentleman, as to copy full length figures in a reduced size, with perfect accuracy, and of an admirable degree of finish.

Progress of Practical and Theoretical Mechanics and Chemistry.

Gilding Copper, Brass, &c.

A patent was granted to George Richards Elkington, of Birmingham, England, for his invention of an improved method of gilding copper, brass, and other metals or alloys of metals.—[Sealed 24th June, 1836.]

This invention consists in gilding copper, brass, and other metals, or alloys of metals, by means of potash or soda combined with carbonic acid, and with a solution of gold.

The patentee states that in order that his invention may be fully understood, he will describe the process, which has been found fully to answer the purpose; the articles operated upon having a very beautiful appearance, and in most instances have been considered to be gilded in a superior manner to those articles submitted to the gilding process where quicksilver is used.

The process of gilding by the aid of quicksilver being well known, and in general practice, no description of it will be necessary. I will, therefore, says the Patentee, first describe the preparation of the materials, and then explain the process of using the same.

Dissolve five ounces, troy weight, of fine gold in fifty-two ounces, avoirdupois weight, of nitro-muriatic acid of the following proportions, videlicet. twenty-one ounces of nitric acid, pur. of 1.45 specific gravity; seventeen ounces of muriatic acid, pur. of 1.15 specific gravity. and fourteen ounces of distilled water.

The gold being put into the mixture of acids and water, they are to be heated in a glass, or other convenient vessel, till the gold is dissolved; and it is usual to continue the application of heat after this is effected, and until a reddish, or yellowish, vapour ceases to rise.

The clear liquid is to be carefully poured off from any sediment which generally appears, and results from a small portion of silver, which is generally found in alloy with the gold. The clear liquid is to be placed in a suitable vessel of stone; pottery ware is preferred. Add to the solution of gold four gallons of distilled water, and twenty pounds of bicarbonate of potash of the best quality; let the whole boil moderately for two hours, the mixture will then be ready for use.

The liquid being thus prepared, and as in practice it is difficult to keep the liquid hot in stone-ware vessels when many articles are being dipped, it has been found advantageous to transfer the liquid to a cast-iron vessel, which it is necessary to keep very clean.

The articles to be gilded having been first perfectly cleaned from scale or grease, they are to be suspended on wires, conveniently for a workman to dip them in the liquid, which is kept boiling. The time required for gilding any particular article will depend on circumstances; partly on the quantity of gold remaining in the liquid, and partly on the size and weight of the article; but a little practice will readily produce sufficient judgment to the workman.

Supposing the articles desired to be gilded to be brass or copper buttons, or small articles for gilt toys, or ornaments of dress, such as ear-rings or bracelets, a considerable number of which may be strung on a hoop, or bended piece of copper or brass wire, and dipped into the vessel containing the boiling liquid above described, and moved therein, the requisite gilding will be generally obtained in from a few seconds to a minute; this is when the liquid is in the condition above described, and depending on the quality of the gilding desired; but if the liquid has been used some time the quantity of gold will be lessened, which will vary the time of operating to produce a given effect, or the colour required, all which will quickly be observed by the workman; and by observing the appearance of the articles from time to time, he will know when the desired object is obtained, though it is desirable to avoid taking the articles out of the liquid as much as possible.

When the operation is completed, the workman perfectly washes the articles so gilded with clean water; they may then be submitted to the usual process of colouring.

If the articles be cast figures of animals, or otherwise of considerable weight, compared with the articles above mentioned, the time required to perform the process will be greater.

In case it is desired to produce what is called a dead appearance, it may be performed by several processes: the one usually employed is to dead the articles in the process of cleaning, as practised by brass-founders and other trades: it is produced by an acid, prepared for that purpose, sold by the makers under the term "*deading aquafortis*," which is well understood.

It may also be produced by a weak solution of nitrate of mercury, ap-

plied to the articles previous to the gilding process, as is practised in the process of gilding with mercury, previous to spreading the amalgam, but generally a much weaker solution; or the articles having been gilded may be dipped in a solution of nitrate of mercury, and submitted to heat to expel the same, as is practised in the usual process of gilding.

It is desirable to remark that much of the beauty of the result depends on the well cleaning of the articles, and it is better to clean them by the ordinary processes, and at once pass them into the liquid to be gilded.

The Patentee says, he has always employed the usual means for cleaning the articles from scales, and other impurities, which are commonly resorted to, in working of the metals for other purposes, when the surfaces are required to be freed from scales or other impurities; and remarks, that great care should be observed in purchasing the articles above described, of the best description.

In conclusion, the Patentee says, "I have described only the using of bicarbonate of potash, which I believe to be the best material for the purpose; and I would remark, that soda in a state of carbonate may be employed, but so far as my experience goes, not with such advantage as potash in a state of bi-carbonate, as above described.

"Having now described the nature of my invention, and the manner of performing the same, I would have it understood, that although, in order to give the best information in my power, I have stated exact quantities of the articles employed, I do not confine myself thereto, nor do I claim any process for cleaning or deading; but what I claim as the improved process of gilding, secured by the present Letters Patent, is the gilding copper, brass, or other metals or alloys of metals, by means of potash or soda, combined with carbonic acid, and with a solution of gold, as above described."

Newton's Jour.

Patented Improvement in the material for Fining or Clarifying Liquids.

A patent was granted to John Dyer, of London, for an improvement in the material used for fining or clarifying liquids.—[Sealed 22d October, 1835.]

The subject of this patent is the production of a material which, when mixed with wine, beer, and some other spirituous and fermented liquors, shall act chemically upon those liquors, for the purpose of dispelling or precipitating such matters held in solution as may have caused the liquors to become turbid.

The material proposed is principally a compound of albumen, carbon, and lime. White of egg and animal blood are suggested as the most convenient matters from whence the purifying materials may be obtained, which are to be evaporated to dryness, and then pulverised.

These matters may be dried either in an open or a close vessel, but a close retort is preferred; and a sand or water bath of 110 deg. Fahr. is proposed as the evaporating medium.

Beside white of eggs and blood, bones may be employed, which should be from young animals, and when perfectly dry are to be pulverised. Clay, or other similar earthy substance, may be used, and also pulverised animal charcoal.

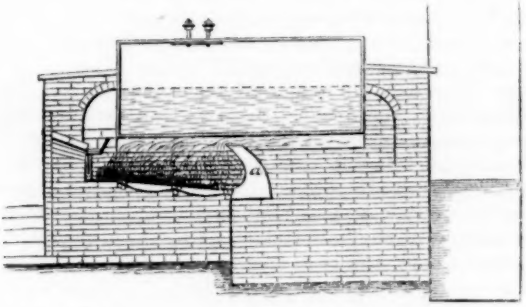
The powders thus produced, may be combined in the proportions of three parts of white of egg to one of blood. About the measure of a cubic inch of this compound, mixed with a small quantity of water, is to be in-

troduced into a pipe of red port wine and stirred up with it, and after a short time the wine will become fine and bright.

A compound of three parts blood, one part bones, and one part yellow marl; or of two parts blood, two parts animal charcoal, and one part bone, all reduced to a fine powder, and mixed with water, may be applied in a similar way to purify white wines, cider, beer, and other liquors.

The Patentee says, in conclusion, he is aware that blood has been used, and also animal charcoal, for clarifying saccharine liquor; he, therefore, does not claim those, unless combined with the other substances; but that which he particularly claims, is "producing the whites of eggs in the state of powder, and compounding them as above described." Ibid.

Description of an improvement in Furnaces for Steam Engine Boilers, &c.
By John Hopkins, of London.



This is a patented improvement. The drawing represents the furnace of a steam-engine boiler, having my improved construction of the fire-bridge made of fire-brick, as shown at *a*, the nature and construction of which will readily be understood by an inspection of the drawing; and it will be seen that the fire-bridge, *a*, in place of rising up and merely intercepting the flames and heated vapours. and causing them to rise upwards and impinge more effectually on the boiler, as has been the construction of ordinary fire-bridges of steam-engines, and other boiler furnaces; the bridge, *a*, shown in the drawing, curves forward, and in addition to causing the flames and heated air to pass upwards, and bring them more closely to the boiler, those flames from the ignited fuel nearest the bridge are turned back, and have a tendency to pass towards the fire-door, and hence the vapours arising from the partially ignited fuel must mix with and be consumed by such flames so directed by the curved construction of the flue, as above described; and it will be evident that in marine and some other construction of boilers the fire-bridge, in place of fire-brick, may be formed of metal, and hollow, for the water of the boiler to pass into and become heated therein, either by pipes connected therewith, or by the bridge being connected to the sides of the boiler, where the construction is such as to have the furnace within; all which will be readily understood by an engineer accustomed to the arranging and constructing of boilers. And it will be evident that, although I have only shown and described furnaces for steam-engine boilers, the invention is equally applicable to the furnaces of other boilers wherein bridges of the ordinary construction have been heretofore used. Repertory of Inven.

Manufacture of Liquid and Paste Blacking.

Specification of a patent granted to William Bryant, and Edward James, of Plymouth, England, for improvements in the manufacture of Liquid and Paste Blacking.—Sealed January 27, 1837.

For the liquid blacking, take India-rubber oil (which consists of eighteen ounces of India-rubber, or a little more or less, according to its quality, dissolved by heat in nine pounds of rape oil;) fine ivory black, sixty pounds; molasses, forty-five pounds; gum-arabic, finely powdered and dissolved in vinegar, one pound; vinegar (No. 24,) twenty gallons; the above to be well mixed and ground in a mill until perfectly smooth, when add sulphuric acid twelve pounds, in small quantities at a time, stirring it briskly for half an hour. Allow it to remain fourteen days, stirring it half an hour every day, then add gum-arabic, finely powdered, three pounds; repeat the stirring for half an hour every day during fourteen days longer, and then it will be fit for use. And for the paste blacking, take India-rubber oil (which consists of eighteen ounces of India-rubber, or a little more or less, according to its quality, dissolved by heat in nine pounds of rape oil;) fine ivory black, sixty pounds; molasses, forty-five pounds; and gum-arabic, finely powdered and dissolved in twelve pounds of vinegar (No. 24.) The above to be mixed and ground in a mill until perfectly smooth, and then add, in small quantities at a time, sulphuric acid twelve pounds, stirring it briskly whilst adding the acid, and for half an hour after the whole is mixed; in seven days it will be fit for use. Ibid.

Improvement in Bread Making.

Specification of the Patent granted to John Whiting, M. D., of Kennington, England, for an improvement in preparing certain Farinaceous Food. —Sealed May 3, 1836.

To form seven pounds of wheaten flour or meal into bread, mix from 350 to 500 grains of the carbonate of soda with about two pints and three-quarters of pure water (the quantity of the alkali may be made to vary within such limits as the baker finds it suit best, and depending on the degree of lightness required.) Mix with three-quarters of a pint of water, in a separate vessel, so much of pure muriatic acid as will neutralize the quantity of the carbonate of soda employed, the quantity of the said acid varying according to the known specific gravity of the acid, and the quantity of soda in the carbonate, which are subjects familiar to chemists. From about 420 to 560 grains of the acid, as met with in commerce, I have found in practice to be required for 350 grains of carbonate of soda; and I would remark, that as bakers are not usually acquainted with chemistry, in order to their adjusting the proportions of the muriatic acid and the alkali, they must depend on some one who is possessed of chemical knowledge. Let the flour be divided into two equal portions; to one portion thrown into a wide earthenware pan or trough, add the solution of the soda gradually, well stirring and beating the mixture with a large wooden spoon, or other convenient instrument, so as to form a uniform batter, free from all lumps. Scrape down into the batter all pieces from the sides of the pan and spoon before the mixing is finished. Upon this batter throw the other portion of the flour, and while briskly stirring them together from the bottom, pour in gradually the diluted acid, then let the dough be formed, and while in a rough state, let it be thrown on the board, and lightly kneaded with a bis-

cuit brake or rolling-pin for a minute or two, doubling and rolling it until it becomes blended and quite uniform and light, but this process must not be continued long. When this is accomplished the dough may be lightly moulded with dry flour, and baked in loaves distinct from each other, and not very large (from a half a pound to a pound and a half weight of dough each.) The bread in some ovens is found to turn out best when baked under tins, in the form called, in London, Coburg or Coronation loaves. The oven should be hot enough to raise the dough quickly, but not so hot as to bind the crust too soon. The bread requires to be well soaked (as it is technically called by bakers,) it being apt to retain too much moisture if it be not sufficiently long in the oven. The process of mixing should be conducted in a cool place, and the water used should be as cold as can be procured, especially in hot weather. Common salt may be added, sufficient to flavour the bread. The quantity of common salt formed by the ingredients used, is about 280 grains, when 350 grains of the aforesaid carbonate of soda are employed, and a little addition of common salt, about half or three-quarters of an ounce, which is to be dissolved in the diluted acid, will generally improve the taste of the bread. The quantity of water above mentioned will be found to correspond with half a pint to one pound of flour, but this must vary with the strength of the flour, and I have found that a rather soft dough is better than that which is stiff. Great care must be taken in the mixing in all cases to secure a perfect union of the acid and alkali, otherwise the bread will be discoloured.

I would remark, that soda and carbonic acid in their other chemical combinations, as the common crystallized carbonate (called sometimes subcarbonate,) or the dried carbonate, or the true bicarbonate, may be employed for the same purpose, care being taken to obtain the extraction of a sufficient quantity of gas, and to form a neutral mixture of the acid and alkali that is to produce common salt.

When eggs or milk, and butter, sugar, and spices, are to be used in making different kinds of light cakes, the same may be mixed with one portion of the flour before the alkali is added to it, and the dough made as above described, and when biscuits are to be formed, the dough may be made as above described, only it must be rendered stiffer by the addition of flour and by pressure, in the manner resorted to in preparing them in the ordinary way.

The flour of rye, and that of barley and oats, when mixed with some of wheat, may be made into bread by the same process, and potatoes (which must on no account exceed one-third by weight of the quantity of flour intended to be made into bread, the other two-thirds being of wheaten flour,) and rice may also be used with wheaten flour, though the bread will be generally considered best if made wholly of wheaten flour. Ibid.

Increased production of Iron.

The quantity of iron made in this country, during the year 1836, has been estimated at the enormous quantity of *a million tons*; the average price of pig-iron, for the year, being about 7*l.* per ton, and that of bar-iron, about 11*l.* per ton. The make of this year, doubtless, far exceeded that of ordinary years, in consequence of the extraordinary impetus given to the iron trade, owing to railway speculations, and other causes; but if we consider the average quantity to be only eight hundred thousand tons per an-

num, which will probably not be far from the truth, the vast amount of wealth thus created by the iron trade alone, must be well calculated to excite surprise and admiration.

Of this large production, we may consider about one hundred and fifty thousand tons to be annually exported to foreign countries, chiefly in a wrought or manufactured state; a large proportion, within the last year or two, being in the form of rails, castings, &c., for the construction of railways. One of our principal exports of iron, during the last year, was to the United States, to be employed in the great projected lines of railway in that country; and a considerable quantity of rails and castings were imported into Russia from England, to be employed in forming the first line of railway which has yet been executed in that country.

The removal of local obstacles to the carrying on of a manufacture of such immense importance, must be regarded as an object of great interest; while any improvement in the manufacture itself, must be considered in the light of a national benefit. We have reason to believe that objects thus important, have lately been effected by the successful application of the carbonaceous variety of coal, termed "anthracite," to the smelting of iron —an experiment has, for some time past, occupied the attention of Mr. CRANE, of the Yniscedwyn iron works, near Swansea, and of which some notice has lately appeared in our columns.

The great coal-field of South Wales is well-known to be one of the most extensive coal districts in Great Britain, and one in which the deposits of this valuable mineral are comparatively little worked; while the rich strata of iron ore, associated with the coal, have rendered it one of the principal seats of our iron manufacture. These great local advantages are, however, in a great measure, confined to the eastern extremity of this coal-field, where the bituminous coal prevails, while a large portion, and more especially towards the western extremity, contains only "stone-coal," or "anthracite," which will not bear coking, and is, therefore, inapplicable to the manufacture of iron. Thus, all the great iron works are situated in the vicinity of Pontypool and Merthyr Tydvil, while none exist farther west. To remove this obstacle to manufacturing industry, both in a large part of South Wales, and other districts similarly situated, has been the object of Mr. CRANE's experiments; and in this, from the information we have received, he has completely succeeded, chiefly by the use of the "hot blast"—the most important modern auxiliary which the art of metallurgy has received.

Independently of the local advantages thus obtained, there is, we understand, a positive benefit derived from the use of this new fuel, as the iron thus made resembles in its qualities the charcoal iron of the continent, which in some respects is of much finer quality than that manufactured in this country, where coke is always used. The great similarity in the chemical composition of anthracite and vegetable charcoal, renders such a result highly probable; and should this be the case, we must congratulate the inventor on having discovered a substitute for a species of fuel which our country is unable to furnish in sufficient abundance for the manufacture of certain qualities of iron.

We are not yet in possession of the details of the improvements alluded to, which, however, we hope shortly to be enabled to lay more fully before our readers—but the subject is of so much interest, as connected with one of our most important manufactures, that we have thus briefly adverted to it without waiting to receive further information. The increasing competition of foreign countries is a circumstance to which we have often alluded,

and we, therefore, hail with pleasure every improvement which, like the present, promises to render more available the vast mineral wealth with which Great Britain has been so liberally gifted by nature, and which requires so great an amount not only of actual labour, but of energy and talent, for its continued and beneficial extraction. Mining Journal.

On the Composition of Bitumens. By M. Bousingault.

The bitumens which are so abundantly spread over the face of the globe, and whose uses are every day becoming more varied and extensive, have hitherto been little examined. If we except the labours of M. de Saussure upon the naphtha of Amiano, we are nearly in complete ignorance concerning the intimate nature of these bituminous compounds.

It is to this insufficiency of the data supplied by chemistry that we must attribute the confusion into which most mineralogists have fallen in their attempts to classify the different bitumens. A systematic place can easily be assigned to naphtha, idrialine, and mellilite or honey-stone, but when we come to petroleum we get involved in difficulties; this substance usually met with in a liquid state, now becomes viscid, and successively presents all possible degrees of consistence, till we arrive at asphaltum, which is solid and brittle. We are generally led to admit that the bitumens owe their fluidity to naphtha; but the results of the present investigation show that there is no ground for this supposition. The attention of the author was first directed to the viscid bitumen of the *Department du Bas-Rhin*. After describing the method in which the bituminous sand is treated, he gives a rapid sketch of the locality of bitumens; and shows that the immense masses of mineral pitch which are found on the banks of the River Magdalena, at Payta, upon the coast of Peru, have a geological position precisely similar to that in which we find bituminous impregnated sands in Europe; that is to say, in formations which we must refer to the supercretaceous group. The only contradictory fact opposed to this conclusion is that recorded by M. de Humboldt, when he states, that at La Punta d'Araya, in the Gulf of Cariaco, he saw petroleum issuing from mica-slate.

The bitumen of Bechelbronn is viscid, of a very deep brown colour. The uses to which it is applied have procured for it the name of mineral grease.

Heated to 120°, this bitumen does not yield any product; but, on distilling it with water, an oily principle is procured, which is volatile, of a pale yellow colour, in which analysis shows there is nothing else than carbon and hydrogen. As this carburetted hydrogen appears to constitute the principal liquid of bitumens, the author designates it by the appellation *Petroline*.

Petroline boils at 280° of the mercurial thermometer; its odour is that of bitumen; at 21° its weight is 0.891, even at a cold of 12° it does not lose its fluidity; alcohol dissolves it in small quantity, and it is much more soluble in ether. It contains carbon 0.885, hydrogen 0.115, and is consequently isomeric with the essential oils of turpentine, lemon, and copaiba.

By using the methods employed by M. Dumas, it is found that the density of the vapour of petroline is equal to 9.415, whilst calculation indicates 9.533. This is precisely double the weight of the vapour of the essence of

turpentine. If we admit that four volumes of vapour constitute an atom of petroline, its atomic composition will be as follows:—

Carbon 80 atoms, . .	3060.8
Hydrogen, 64 atoms, .	400.0
	3460.8

Independent of the petroline, there exists in the bitumen a black solid substance, which is absolutely insoluble in alcohol, and soluble in ether. M. Boussingault names this product *Asphaltine*, because it forms the base of that species of mineral which mineralogists describe under the name of asphaltum.

Asphaltine may be procured by subjecting bitumen purified by ether to the continued action of a temperature of 240° or 250°. Asphaltine is solid, very black and brilliant, its fracture conchoidal; at a temperature of 300° it becomes soft and elastic, and is decomposed before the blowpipe. It contains Carbon, 0.753; Hydrogen, 0.099; Oxygen, 0.148, a composition which is represented by the formulary $C.^{80}. H.^{64}. O^{6}$. which indicates that asphaltine is the result of the oxidation of petroline.

The bitumen of Bechelbronn, purified by ether, seems to be nothing more than a mixture of petroline and asphaltine. It contains Carbon, 0.870; Hydrogen, 0.112; Oxygen, 0.018.

On the whole, then, it would appear that glutinous bitumens are mixtures, probably in all proportions, of two substances, which we can isolate, and which have each a difinite composition. One of these principles is solid and fixed, and in its nature approaches to asphalt; the other liquid, oily, and volatile, resembles petroleum in some of its properties. Hence we may readily conceive how the consistence of bitumens varies in a way we may call indefinite; its degree of fluidity being regulated by the relative proportion of the mixture of its ingredients.

The analogy which exists between the asphaltine and the asphaltum of mineralogists, led me, says the author, to inquire if this analogy is maintained in their composition; I have submitted the asphaltum of Coxitambo (Peru,) which may be considered as the type of the species, to analyses. This asphaltum has a fracture which is eminently conchoidal, with a high degree of lustre. The weight is 1.68; it is decomposed before the blowpipe, and when burned leaves 0.0016 residuum. It contains Carbon, 0.750; Hydrogen, 0.095; Oxygen, 0.155. Edin. New Philos. Jour.

Watch Statistics.

Mr. Dent, (Arnold and Dent,) in his illustrations at a lecture on the construction of watches and chronometers, given by him at the Royal Institution on the 7th ult., laid before the meeting the dissection of a detached lever watch (compensation-balance,) every part was separated and displayed, but grouped in one of six larger divisions to which it belonged.

Each part had been previously examined, and its distinct constituent pieces counted by the lecturer; the surprising result of this enumeration was exhibited in a table, of which we lay a copy before our readers. In addition, will be found the number of kinds of artificers concerned in the operations necessary for the construction of a good watch. When to these are added the amount of previous operations which the materials constituting each piece must undergo, *before* it comes into the hand of the watch-artificer, a glimpse may be obtained of the extensive and numerous changes of form

and value which "raw material" receives in its progress, from the mine to so refined a manufacture as a finished watch.

No. of Parts.	No. of Pieces.	Trades employed.
1. Pillars	4	1
2. Frame	4	1
3. Cock and Potence	2	1
4. Barrel and Arbor	3	1
5. Going-Fuzee	14	2
6. Wheels	4	1
7. Pinions	4	2
8. Stop-Stud	1	1
9. Stop and Spring	3	1
10. Click and Ratchet	3	1
11. Motion	16	2
12. Jewels (5 holes)	28	2
13. Cap	3	2
14. Dial	3	3
15. Index	1	1
16. Escapement	13	3
17. Compensation-Balance	9	1
18. Case	3	1
19. Pendant	2	1
20. Case-Joint	6	1
21. Case-Spring, &c.	4	2
22. Main-Spring	1	2
23. Chain	826	3
24. Hands	3	1
25. Glass	1	1
Total of Pieces	992	
Engine-Turner		1
Engraver		1
Gilder		1
Examiner		1
Total of kinds of Artificers employed		43

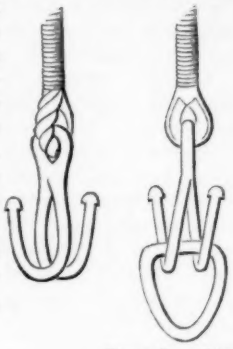
Mag. Pop. Sci.

Double Hook.

The thanks of the Society were voted to Lieutenant G. Beadon, R. N., for his Double Hook; one of which has been placed in the Society's Repository.

It appears that single hooks are in use in the navy, for the purpose of hoisting packages and other articles on board ship, and that, to prevent accidents, a general order is given that no article is to be hoisted on board unless the hook has been first *moused*, that is, unless a piece of yarn has been passed round the end of the hook and the opposite part of the shank, so as to prevent the article from slipping off. A scrupulous adherence to the above order was the occasion of a package of dollars being lost in transferring it from a boat to the deck of a frigate on the coast of Peru, in which Lieutenant Beadon was at that time serving; for, just as the hook had been passed

under the cording of the package, and before it had been moused, a roll of the ship raised it out of the boat. The package might, with perfect safety, have been hoisted on board; but the order about mousing the hook not having been complied with, the package remained dangling at the end of the rope, and, as the ship rolled back again, was struck by the gunwale of the boat and thrown off the hook into the sea.



To avoid such accidents, Lieutenant Beadon has invented a double hook, as shown in the annexed figure, the two bends of which point in opposite directions, and each bend has a double set, somewhat like a fish-hook. A hook of this description will, apparently, require no mousing, and is easily both made fast and disengaged.

Trans. Soc. of Arts.

Progress of Physical Science.

Phenomena of Petrifaction.

The petrifaction of wood, and more especially its silicification, still continues to present obscure problems to the botanist and chemist. The first step towards their solution will probably be made by carefully examining vegetables in different stages of petrifaction; and with this view Mr. Stokes has procured several specimens of wood, partly mineralized and partly not. Among these is a piece found in an ancient Roman aqueduct in Westphalia, in which some portions are converted into spindle-shaped bodies consisting of carbonate of lime: while the rest of the wood remains in a comparatively unchanged state. The same author has pointed out cases both of siliceous and calcareous fossils where the lapidifying process must have commenced at a number of separate points, so as to produce spherical, or fusiform, petrifactions, independent of each other, in which the woody structure is apparent, while in the intervening spaces the wood has decayed having, after removal, been replaced by mineral matter. In some petrifactions, the most perishable, in others the most durable, portions of plants are preserved, variations which doubtless depend on the time when the mineral matter was supplied. If introduced immediately on the first commencement of decomposition, then the most destructible parts are lapidified, while the more durable do not waste away till afterwards, when the supply has failed, and so never become petrified. The converse of these circumstances gives rise to exactly opposite results. As to the manner in which the minutest pores and fibres discoverable by the microscope, even the spiral vessels themselves can be turned into stone, or have their forms faithfully represented by inorganic matter, no satisfactory explanation has ever yet been offered. In considering, however, this question, you will do well to consult the important suggestion which a celebrated chemist, our late lamented Secretary, Dr. Turner, has thrown out on the application of chemistry to geology. He reminds us that whenever the decomposition of an organic body has begun, the elements into which it is resolved are set free in a state peculiarly adapting them to enter into new chemical combinations. They are in what is technically termed a nascent state, the constituent molecules being probably of extreme smallness and in a fluid or gaseous form, ready to obey the slightest impulse of chemical affinity, so

that if the water percolating a stratum be charged with mineral ingredients, and come in contact with elements thus newly set free, a mutual action takes place, and new combinations result, in the course of which solid particles are precipitated so as to occupy the place left vacant by the decomposed organic matter. In a word, all the phænomena attendant on slow putrefaction must be studied whenever we attempt to reason on the conversion of fossil bodies into stone; and in regard to silicification, Dr. Turner has shown how great a quantity of silex is set free as often as felspar decomposes, and how abundantly siliceous matter may be imparted from this source alone to running water throughout the globe.

As I have mentioned the name of Dr. Turner, I cannot pass on without an expression of sorrow for the untimely death of that amiable and distinguished philosopher. Mr. Whewell and Mr. Murchison alluded in most feeling terms this morning at the General Meeting to this melancholy event, which is too recent and too painful to myself and others to allow me now to dwell longer upon it.

Before quitting the subject of vegetable petrifactions, I ought to mention a memoir just published, by Mr. H. R. Goppert, Professor of Botany at Breslau, "On the various Conditions in which Fossil Plants are found, and on the Process of Lapidification."* He has instituted a series of most curious experiments, and his success in producing imitations of fossil petrifactions has been very remarkable. I have only space to allude to one or two examples. He placed recent ferns between soft layers of clay, dried these in the shade, and then slowly and gradually heated them, till they were red hot. The result was the production of so perfect a counterpart of fossil plants as might have deceived an experienced geologist. According to the different degress of heat applied, the plants were obtained in a brown or perfectly carbonized condition, and sometimes, but more rarely, they were in a black shining state, adhering closely to the layer of clay. If the red heat was sustained until all the organic matter was burnt up, only an impression of the plant remained.

The same chemist steeped plants in a moderately strong solution of sulphate of iron, and left them immersed in it for several days until they were thoroughly soaked in the liquid. They were then dried and kept heated until they would no longer shrink in volume, and until every trace of organic matter had disappeared. On cooling them he found that the oxide formed by this process had taken the form of the plants. Professor Goppert then took fine vertical slices of the Scotch fir, *Pinus Sylvestris*, and treated them in the same way; and so well were they preserved, that, after heating, the dotted vessels so peculiar to this family of plants were distinctly visible. A variety of other experiments were made by steeping animal and vegetable substances in siliceous, calcareous, and metallic solutions, and all tended to prove that the mineralization of organic bodies can be carried much farther in a short time than had been previously supposed.

These experiments seem to open a new field of inquiry, and will, I trust, soon be repeated in this country. In endeavoring, however, to verify them, the greatest caution will be required, or we may easily be deceived. We must ascertain, for example, with certainty, that every particle of animal or of vegetable matter is driven off before we attempt to determine the full extent to which mineralization may have proceeded. Professor Goppert is doubtless aware that coniferous wood may be burnt and reduced to

* Poggendorff, Annalen der Physik und Chemie vol. xxxviii. part 4. Leipsic, 1836.

charcoal, and after having been kept for some time at a red heat, will continue to exhibit, on being cooled, the disks, or reticulated structure, to which he alludes. If, therefore, some small particles of carbon remain in the midst of the oxide of iron, such portions may retain traces of the vessels peculiar to coniferous wood; and an observer not on his guard, might infer that the same structure was preserved throughout the mass.

In my last address, I alluded to Mr. Lonsdale's detection of vast numbers of microscopic corallines and minute shells in the substance of the white chalk of various counties in England, where this rock had not been suspected of consisting of recognisable organic bodies. I cannot deny myself the pleasure of mentioning the still more singular and unexpected facts brought to light during the last year, by Professor Ehrenberg of Berlin, respecting the origin of tripoli. I need scarcely remind you, that tripoli is a rock of homogeneous appearance, very fragile and usually fissile, almost entirely formed of flint, and which was called polir-schiefer, or polishing slate, by Werner, being used in the arts for polishing stones or metals. There have been many speculations in regard to its origin, but it was a favorite theory of some geologists that it was a siliceous shale hardened by heat. The celebrated tripoli of Bilin in Bohemia consists of siliceous grains united together without any visible cement, and is so abundant that one stratum is no less than fourteen feet thick. After a minute examination of this as well as of the tripoli from Planitz in Saxony, and another variety from Santa Fiora in Tuscany, and one from the Isle of France, Ehrenberg found that the stone is wholly made up of millions of siliceous cases and skeletons of microscopic animalcules. It is probably known to you, that this distinguished physiologist has devoted many years to the anatomical investigation of the infusoria, and has discovered that their internal structure is often very complicated, that they have a distinct muscular and nervous system, intestines, sexual organs of reproduction, and that some of them are provided with siliceous shells, or cases of pure silex. The forms of these durable shells are very marked and various, but constant in particular genera and species. They are almost inconceivably minute, yet they can be clearly discerned by the aid of a powerful microscope, and the fossil species preserved in tripoli are seen to exhibit, in the family Bacillaria and some others, the same divisions and transverse lines which characterize the shells of living infusoria.

In the Bohemian schist of Bilin, and in that of Planitz in Saxony, both of them tertiary deposits, the species are freshwater, and are all extinct. The tripoli of Cassel appears to be more modern, and the infusoria in that place which are also freshwater, are some of them distinctly identical with living species, and others not. In the tripoli brought from the Isle of France, the cases or shells all belong to well-known recent marine species.

The flinty shells of which we are speaking although hard are very fragile, breaking like glass, are therefore admirably adapted when rubbed for wearing down into a fine powder fit for polishing the surface of metals. It is difficult to convey an idea of their extreme minuteness, but I may state that Ehrenberg estimates that in the Bilin tripoli there are 41,000 millions of individuals of the *Gaillonella distans* in every cubic inch of stone. At every stroke therefore of the polishing stone we crush to pieces several thousands if not myriads of perfect fossils.—*Extracted from the Anniversary address before the Geological Society of London, by the President Charles Lyell, jun. Esq.* 1837. Lond. & Ed. Philos. Mag.

Action of Presence.

The 60th volume of the *Annales de Chimie et de Physique* contains a paper by Pelouze on a new acid, which he calls *nitrosulphuric acid*. Speaking of the salt which this forms with ammonia, he says, "the excessive mobility of the elements of nitrosulphate of ammonia, and the stability which the alkales impart to them, made me think it not impossible that this salt might exhibit phænomena of decomposition of the same class as the singular ones which M. Thenard observed with binoxide of hydrogen. In fact this is the case; many substances which decompose binoxide of hydrogen, without either acquiring or losing anything, also decompose the nitrosulphates. Spongy platina, oxide of silver, metallic silver, powdered charcoal, and oxide of maganese, produce this effect; the two first-mentioned especially, act with extreme rapidity upon the nitrosulphate of ammonia.

"I convinced myself," continues M. Pelouze, "that this remarkable phænomenon was due, as in the case of binoxide of hydrogen, to *an action of presence* (à une action de presence,) and that it never produces more than a mere conversion of nitrosulphate of ammonia into protoxide of azote and sulphate of ammonia. Oxide of silver is not reduced, for if it be washed after having caused it to decompose a large quantity of this salt, it afterwards dissolves in nitric acid without the disengagement of red vapours."

M. Pelouze afterwards remarks that "it would be very difficult to discover the probable cause of these singular phænomena; but from the very circumstance of their being at present inexplicable, they appeared to me the more to merit the attention of chemists. What indeed is more calculated to excite curiosity than to observe a salt, by the mere contact of a body which neither yields anything to nor takes any thing from it, decompose with extreme rapidity into new forms, among which the agent producing these violent actions remains chemically passive.

"Two compounds, namely, binoxide of hydrogen and hydruret of sulphur, are already known as possessing the property of decomposing by the influence of a simple action of presence."—*Ann. de Ch. et de Phys.*, lx. 158.

L. & E. Philos. Mag

Catalysis.—Action of Presence.

In the 61st volume of the *Ann de Ch. et de Phys.*, Berzelius has followed up the remarks of Pelouze *on the action of presence*, and has given to it the name of *Catalysis*. His notice on this subject is entitled, "*Some ideas on a new force acting in the combinations of Organic Compounds.*"

In inorganic nature, new combinations are formed between the different bodies which are present, because these bodies have a greater tendency to combine with each other than with other bodies. Those bodies which have a great affinity for each other, combine together, and reject those for which they have a weaker affinity, and with which they were previously combined; and these also combine together. Until the year 1800, this tendency of bodies to unite was the only one known, except that heat, and in some cases light, could effect their combination. The influence of electricity was of later discovery, but it was soon also discovered that chemical and electrical affinity were the same, and that heat and light acted only by increasing or diminishing these affinities. On proceeding to

the study of organic chemistry, very different bodies were obtained from the same crude material by different organs. In animals, this crude material, which is the blood, flows in the uninterrupted vessels, and gives rise to all the different secretions; such as milk, bile, urine, &c., without the presence of any foreign body which could form new combinations.

Kirchoff discovered that starch dissolved in acids diluted with water was converted at a certain temperature into gum, and then into sugar of grapes; and yet there was no combination between the elements of the acid and those of the starch, for no disengagement of gas took place. On treating the solution with bases, all the acid employed was regained; the solution contained only sugar, the weight of which only slightly exceeded that of the starch employed. Some time afterwards, Thenard discovered a new substance, the binoxide of hydrogen, the elements of which are held together by very slight affinity. This substance was not decomposed by acids, but alkalies gave its elements a tendency to separate; slow effervescence occurred with the disengagement of oxygen, and water was formed. It was soon found not only that soluble substances produced this effect, but also that other organic and inorganic bodies, such as manganese, silver, platina, gold, fibrin, &c., acted in the same manner upon it. This decomposition takes place by the mere presence of the foreign body, in consequence of a power which is at present unknown, and without the smallest quantity entering into the new compound, for the most minute researches failed in discovering the slightest alteration in it.

Edmund Davy discovered that if extremely finely divided platina be moistened with alcohol, this on taking fire ignites the platina, and the alcohol, if it contains water, is converted into acetic acid. This led to the grand discovery of Dœbereiner, that spongy platina has the property of firing a current of hydrogen directed upon it. This discovery was soon followed by that of Dulong and Thenard, who found that it was not platina alone that possessed this property, but that other bodies, such as gold, silver, and glass, acted in the same way, but only when they are exposed to a somewhat high temperature; whereas platina, iridium, and other metals which accompany platina, produce this effect even much below the temperature of melting ice.

The analogy was observed which exists between the phenomena of the conversion of sugar into alcohol by the presence of a foreign insoluble body, and that of the decomposition of peroxide of hydrogen into water and oxygen, by the presence of platina, silver, fibrin, and some other equally insoluble bodies. No case analogous to that of the decomposition of binoxide of hydrogen by the presence of the alkalies dissolved in this substance was known, for at this period the analogy of this phenomenon with that of the formation of sugar by means of starch and sulphuric acid was not known. Something similar occurs in one of the hypotheses on the formation of ether. According to this hypothesis, sulphuric acid should combine with one part of the water contained in the alcohol, and thus would form ether; but it could not be explained why other bodies, such as potash, chloride of calcium, quicklime, &c., which have a very great affinity for water, did not produce the same effect. Mitscherlich showed that if alcohol be poured upon sulphuric acid, at a temperature higher than that of boiling water, water and ether are distilled together, and form a mixture the weight of which is precisely equal to that of the alcohol employed. Thus the sulphuric acid does not there act in consequence of its affinity for water; its action is analogous to that of the alkalies on the binoxide of

hydrogen; and that of sulphuric acid upon starch in the formation of sugar.

It is then proved that many bodies, both simple and compound, soluble and insoluble, have the property of exerting on other bodies an action which is very different from chemical affinity. By means of this action they produce decompositions in bodies, and form new compounds into the composition of which they do not enter.

This new power, hitherto unknown, is common, both in organic and inorganic nature. I do not believe that it is a power which is entirely independent of the electro-chemical affinities of the substance; I believe, on the contrary, that it is merely a new form of it; but as long as we do not see their connexion and mutual dependence, it will be more convenient to describe it by a separate name. I shall therefore call it *catalytic power*. I shall also call *Catalysis* the decomposition of bodies by this force, in the same way as the decomposition of bodies by chemical affinity is termed analysis.

The following are the questions which occur relative to this catalytic power.

Can this catalytic power produce differences in catalytic products, according to its greater or less intensity?

Can different bodies possessing catalyic power produce different catalytic effects upon the same compound substance?

Can bodies which possess catalytic power exert this action on a great number of different compound substances, or is this action confined to a few substances?

These questions can be answered only by extended researches; it is enough at present to have established the existence of this power by a sufficient number of examples. This power gives rise to numerous applications in organic nature; thus it is only around the eyes of the potatoe that diastase exists; it is by means of catalytic power that diastase, and that starch which is insoluble, is converted into sugar and into jam, which being soluble form the sap that rises in the germ of the potatoe. This evident example of the action of catalytic power in an organic secretion is not probably the only one in the animal and vegetable kingdoms, and it may hereafter be discovered that it is by an action analogous to that of catalytic power that the secretion of such different bodies is produced, all which are supplied by the same matter,—the sap in plants and the blood in animals.

Lon. & Ed. Philos. Mag.

On Solid Carbonic Acid.

Letter from M. Thilorier to the Academie des Sciences of Paris.—"I have the honour of now announcing to the Academy that I have just finished a second memoir upon liquid carbonic acid, in which, after having successfully examined the different parts of this body, its *specific gravity*, which is so variable that, from 32° to 86° Fahr., it successively runs through the whole scale of densities from water to that of ethers; its *dilatability*, which is four times greater than that of air itself; its *pressure* and the *weight* of its vapour; its *capillarity*, and especially its *combressibility*, which is a thousand-fold greater than that of water, I have succeeded in determining in the most exact manner, the uniform and constant law which regulates all these phenomena, which at first view appear altogether independent of each

other. The Academy will without doubt learn with interest, that, by means of a very simple apparatus, I have succeeded in producing instantly, and economically, masses of solid carbonic acid weighing an ounce and an ounce and a quarter, and which the experimental chemist may beneficially employ My first experiments on cold, which I have already presented to the Academy, were made by directing a stream of liquid carbonic acid upon the bulb of a thermometer, or on tubes which enclosed the different substances upon which the action of the cold was tried. This method had the serious inconvenience of wasting a great quantity of the liquid, and of leaving some uncertainty upon the maximum of the cold produced. The facility and abundance with which I now obtain the solid carbonic acid has supplied me with a method of experimenting which is infinitely preferable. The bulb of the thermometer having been introduced into the centre of a small mass of solid carbonic acid, at the end of one or two minutes the thermometer became stationary and stood at —194° Fahr. Some drops of ether and of alcohol poured upon the solid mass did not produce any appreciable difference less or more on the temperature. Ether forms a mixture which is half liquid, and of the consistence of melting snow; but alcohol, in combining with solid carbonic acid, congeals, and produces a hard, brilliant, and semi-transparent ice. This freezing of anhydrous alcohol only takes place in the act of mixture; when isolated, as in a silver tube, in the midst of a mass of solid carbonic acid, the alcohol undergoes no change whatever. The mixture of alcohol and solid carbonic acid begins to melt at —185° Fahr. and starting at this point, the temperature does not vary any more. Thus we can obtain from this extreme limit a point as fixed as is supplied by that of melting ice. If, after having formed *a small coppel* of solid carbonic acid, we pour into it three or four drachms of mercury, it is seen to congeal in a few seconds, and to remain in this new condition so long as an atom of solid carbonic acid remains, that is to say, for twenty or thirty minutes when the weight of the coppel is from two to three drachms. I have already said that the addition of ether or alcohol did not augment the real degree of the cold, but, by giving the solid carbonic acid the power of moistening bodies, and of adhering more intimately to their surface, these substances much increase the frigerating effects. A piece of solid carbonic acid, on which some drops of ether or alcohol are poured, becomes capable of congealing fifteen or twenty times its weight of mercury. The promptitude with which it is converted into the solid state, the mass in which it is effected, and which may easily exceed half a pound, and its continuance in this new condition, which may be maintained as long as you like, with the single precaution of placing the metallic mass upon a base of solid carbonic acid, leads me to believe that this method of freezing mercury will henceforward be substituted for all those which have been previously employed."

Edin. New Philos. Jour.

Progress of Civil Engineering.

Architectural Hints.

An idea for forming artificial gardens in confined spaces at the back of houses in town, was once started to me by a friend, which I consider too good to be lost, although it may startle many, at first, as an extravagant absurdity. It was, to have branches of plants and flowers, moulded in earthenware, and painted of their natural colours, but unglazed, and after

wards affixed to real stems, planted either in beds or spots. These would produce a lively and cheerful appearance, as seen from the window of a back parlour, and would constitute a perennial garden in full bloom at all seasons, and let the situation be what it might; while, during the summer, pots with real shrubs and plants, might either take the place of, or be intermixed with, the others. Nor, were the practice adopted, and manufactories for the purpose established, would the expense of such artificial plants be very great, at least not for a sufficient quantity to make a decent show, and screen dead walls; because, being intended to be seen only from a distance, they would not require to be nicely finished or coloured, nor to have more pains bestowed on them than would suffice to produce the desired effect, so that they might be manufactured by children. "Still," cries an objector, "it would be mere make-believe." Certainly: so is gilding, or painting in imitation of grained woods; and I admit that it would be supremely foolish for any one to put himself to the expense of such a deception, if he were equally well satisfied with having before his eyes a forlorn looking, dingy yard, styled by courtesy a garden, with a few leafless and stunted plants stuck in it. Nay, after all, whether absurd or not, that something of the sort has already been practised with tolerably good effect, may be learned from the publication I have already quoted, and which deserves to be quoted again. "The Italian taste in chimneys," says the author of *Slight Reminiscences*, "is peculiarly elegant; no matter how mouldering, raw, or staring the house may be, there is always something graceful and redeeming about this generally frightful utility. We stepped out from the show apartments of the Palazzo Brignoli, at Genoa, on a spacious terrace, which constitutes the roof of another part of the building. The chimneys were placed at regular intervals, each having the form of a column, ornamented with trophies, and terminated by a vase, containing an aloe, or something that looked like one. The effect was so good that we believed them to be merely decorative, until our cicerone pointed out to us a light smoke issuing from the centre of the leaves." If, therefore, a deception of that kind was allowable, there would hardly be anything very extravagant in one that would not be quite so much at variance with *vraisemblance*. Arch. Mag.

On an Improved method of Teaching Drawing; by John Robison, Esq.

From an article in the appendix to "Lectures on Popular Education, by George Combe."

"It appears to me," Mr. Robison observes, "that every one who can write is capable, with a slight effort, of making every line or mark which is wanted in order to represent any object presented to him. It is not, therefore, the mechanical use of the pen or the pencil which requires to be taught, so much as the art of looking at objects, and *of recognising what we really see*. When the habit of noting the true visual forms of objects has been acquired (which it will soon be, if cultivated under the directions of an intelligent instructor,) the power of delineating the outline will not be long found wanting; the perception of the effects of light and shade may be acquired in the same way, and they will then be rendered on paper by the pupil with a degree of truth which he could not attain by any time or labour spent in copying the drawings of others.

"If a young, or uninstructed, person be required to make a representation of such an object as a common pencil, he will probably proceed to mark on

his paper an outline of the actual length and breadth of the pencil, but he will be at a loss to show that it is round and not square; again, he will not be able without consideration, or perhaps explanation, to delineate on paper the different appearances which the pencil assumes when held nearer to or further from the eye; or in positions more and more oblique until nothing be seen but the circular end. A little pains on the part of the instructor would lead a pupil to observe and comprehend all that is required to do this, by making him attend to what he really sees; and the lesson, when once acquired, would be in little danger of being forgotten, although it in fact include the whole doctrines of perspective.

"In forming any institution for teaching drawing *as an useful art*, I should therefore propose that the pupils should, from the very commencement, be exercised in noting and delineating the appearances of a few simple objects, presented to their view at varied distances, heights, and degrees of inclination. A convenient object may be found in a cubical box of wood, fitted to slide on an upright rod or stand, on which it may be fixed at any desired height by a hollow through its axis. If this model be set in front of a pupil, at such a distance that it can be conveniently seen, and its height be made that of his eye, and one of the sides be parallel to his face, then on noting its appearance, he will soon observe that it may be represented by a square outline, parallel to the sides of his paper. If the model be then raised by sliding it up the rod, the pupil will find that a change in the *apparent* form has taken place, and that his outline must include a representation of the bottom, which he will be enabled to give, by combining his present observations with what he learned in studying the changes of position of the pencil in the earlier lessons. He will also find, that the degrees of light falling on the two faces which he now sees are different, and require different shadings from the pencil. In the first case, the single face of the cube which he saw may have been either lighter or darker than the distant back-ground, and in the delineation some shading may have been required on the back-ground, or on the object, according to which appeared darkest to him; but, in this second case, he may have three degrees of light to represent, according to existing circumstances. In the same way, the position of the model may be varied, both in respect to figure and to light; or, if a class be under instruction, the pupils may interchange their places round the object, and each in succession take similar views, and compare the results at the conclusion of each series.

"It is obvious that such a system of instruction may be pursued to a great extent, and with the variations which may be required according to the views of the pupils; and that, even for those who intend to pursue the higher branches of the Fine Arts, a better foundation could hardly be given for enabling them to understand and profit by the examples left by the great masters." Ibid.

Proposed Railways in England.

"The number of proposed railways, including diversions, extensions, and branches, in England and Wales, for which plans have been lodged in the Private Bill Office in the present session, is seventy-five, of which only forty-eight are under the consideration of Parliament; these amount in length to twelve hundred and thirty-three miles, and are estimated at the sum of of nineteen millions three hundred and fifty-two thousand seven hundred

and twenty-six pounds,* or fifteen thousand six hundred and ninety-five pounds per mile. The whole length of tunneling is twenty-five miles; and ehe number of bridges, exclusive of viaducts and culverts, two thousand tight hundred and twenty-five, or nearly two and a third per mile. The weight of iron required for the rails, is one hundred and ninety-three thousand five hundred tons; and of stone for the blocks two millions six hundred and seventy thousand tons. The area of land required to be taken, is upwards of fifteen thousand acres; and of felt for the chairs, one hundred and thirty acres. These railways, if carried into execution, would employ at least five thousand men and fifteen hundred horses for three years.† The principal competing lines are the five Brighton, the two Birkenhead and Chester, and the South Union, and Manchester, Cheshire and Staffordshire Railways.

"The proposed railways in England and Wales, abandoned in the present session, are twenty-seven in number, amounting in length to seven hundred and ninety-four miles; the length of tunneling is about eight and three-quarter miles; and the number of bridges one thousand five hundred and ninety-five, or about two per mile." Mining Jour.

Locomotive Engine.

Locomotive engines of very imperfect construction were in use for a long time previously to their introduction on public railways. The Stockton and Darlington Railway is the first on which this master-piece of human skill was introduced as a substitute for horse-power. Many of the engines still used on this line are very ponderous and clumsy, but still they are powerful. The Lord Brougham may be quoted as an example; it is an engine sixteen feet in length, supported on six heavy wheels, each three being connected together by cranks; these wheels are each four feet in diameter, the whole weight is about twelve tons. The two cylinders are placed in front of the chimney, and are each fourteen inches in diameter, the piston of each working vertically, and communicating with the cranks beneath, attached to the wheels.

"On the Manchester and Liverpool Railway, the proportion of the number of engines in daily use, is almost one to every three miles, and about as many more under repair: among those at present in use may be mentioned, the Collier, the Mercury, the Rapid, the Hercules, the Ajax, the Speedwell, and the Thunderer. Some of these engines were built by Messrs. Taylor and Co., of the Vulcan Foundry, near Warrington.

"On the Dublin and Kingstown Railway, where the passenger traffic is very considerable, the trains starting from either end of the line, almost twenty times a day, the number of engines is nine; they are severally called the Manchester, the Britannia, the Vauxhall, the Kingstown, the Dublin, the Comet, the Victoria, and the Stanley. Three of these were built by Messrs. Sharp and Roberts, of Manchester, and have eleven-inch cylinders, and sixteen-inch stroke; and the remainder by Mr. Forrester, of the Vauxhall Foundry: the weight of these engines is from about nine to ten tons; many of them are of elegant design.

"On the Leicester and Swanington Railway, where the tonnage of coal

* This sum is exclusive of four of the proposed Brighton lines, one of the Southern lines from Manchester, one of the Birkenhead and Chester lines, the Great Western, Southampton, North Midland, and Eastern Counties' Diversions; and also the line from Gillingham to Exeter.

† For the earthworks alone.

alone, from Mr. Stephenson's and other collieries, is about 500 tons a-day, the number of engines is seven, viz. the Comet, the Hercules, the Goliah, the Vulcan, the Atlas, the Sampson, and the Liverpool.

"The Atlas and Vulcan, each with six wheels, are two of the most powerful engines at present in use, on any line of railway, having cylinders of sixteen inches diameter, and twenty-inch stroke; they are built for heavy loads and slow speeds.

"The Hercules, Goliah, and Samson, have each fourteen-inch cylinders, and eighteen-inch stroke; and, lastly, the Comet and Liverpool, twelve-inch cylinders, and fourteen-inch stroke.

"The valuable work on locomotive engines by the Chev. de Pambour, contains the best possible information with regard to the construction of the locomotive engine." Ibid.

Mineral Resources of Belgium.

The following is extracted from the "Almanack Belge," a publication containing much useful statistical information, and which affords the best summary we have yet seen of the mineral resources of that country :—

"Belgium possesses beds of coal and iron mines, more valuable than the silver veins of Peru, or the gold of Brazil. The coal-beds of Belgium are superior to any on the European continent. In the basin of Mons, for instance, we find from a hundred and ten to a hundred and twenty strata, or layers of coal, disposed one above another, all workable, and all wrought. The four principal collieries of Mons, Marimont, Liege, and Charleroi yield annually 3,200,000 tons of coal. The whole produce of the French coal-pits, in 1834, did not exceed 2,500,000 tons. Nor is belgic industry less striking as regards iron than it is with respect to coal. It is remarkable, and somewhat inexplicable, that, to this day, no attempt for the fabrication of iron after the English fashion—that is, by extracting it from the iron-stone or ore (by means of coal or coke)—has succeeded in France, though many districts abound in natural advantages for the purpose. In Belgium, on the contrary, the undertaking has been accompanied with the most marked success. Seven years ago (in 1830,) some capitalists at Charleroi erected a furnace, where they treated the mineral of the district with the coal which likewise exists there. On the first trial, an article was produced which was greedily bought up by the Parisian iron-founders. From that time till this, establishment has followed establishment so rapidly, that, in the district of Charleroi alone, there are, at this day, twenty-five coke-furnaces in action, producing annually 75,000 tons of metal, without reckoning furnaces where wood is employed. In 1834, the iron produce of all France, from the combustible mineral as in Belgium, amounted only to 47,000 tons; the French castings in the same year, of every kind, amounted in the whole to 269,000 tons. So rich in iron and coal, Belgium could not fail to have flourishing manufactures; the woolen stuffs of Verviers, and the flaxen goods of Flanders, are familiar to the world.

"It is known that the French manufacturers of linen, woolen, and other soft goods, have declared the impossibility of competing with the manufacturers of Verviers and Ghent, on account of the greater excellence and abundance of the landed produce, lint, flax, &c. of Belgium; and it is also known, that the iron-workers of France have expressed similar opinions, on the ground of the greater fertility of Belgium in coal. Thousands of French operatives, it is said, have been reduced to beggary from these

causes. These remarks are confirmed by the conduct of the French government, which in consequence of the national inferiority in these respects, has judged it impolitic to unite France and Belgium by the strong bond of a commercial association. By this conduct, however, a chance has been left of the accession of Belgium in self-defence to the Prussian commercial league, which is decidedly hostile in its tendency to the interests of France.

"The Belgians follow out their manufacturing and mining pursuits with a boldness and energy most honorable to the national character. Six hundred feet was not long ago reckoned an extraordinary depth to push a mine down into the earth; recently, the Belgian miners have penetrated above thirteen hundred feet; they wrestle fearlessly with subterranean torrents, and with steam-engines raise their waters from their hidden sources. With the lamp of Davy, they defy the treacherous air-damp, which has involved so many in instantaneous destruction. Not less active and industrious are those among the labouring classes of Belgium, whose lot it is to toil in the eye of day.

"While the French are building senseless monuments, the Belgians are busily raising structures for manufacturing industry such as fabrics for the reception of furnaces, plating or boring machines, or forges. One capitalist of Belgium has been known to erect, for the convenience of his own individual business, more buildings than the French artillery destroyed at Antwerp. The establishment of Searing, near Liege, extends, in regular buildings, for a quarter of a league (three quarters of an English mile.) On the side opposite the Meuse are situated the mines, from which issue the mountains of coal, to be converted into coke. Next to these are the great round towers, sixty feet high, and fortified with iron, from the mouths of which flames are continually darted as from a crater. One of these furnaces has been in action for six years, and during that time there have been thrown into it, each day, nearly one hundred thousand killogrammes of materials. The numerous other buildings attached to this establishment are filled with steam-engines, forges, refining places, &c. Almost ere the manufactured iron be cold, it is delivered over to expert artisans, well provided with every species of instrument, who make from it machines and tools of all possible kinds, and, above all, rails for railways, which may be regarded as a sort of steam-horses, surpassing all the Arabian barbs that ever cropped the scanty herbage of the desert. The whole neighborhood of this establishment is traversed by railroads and canals. The workmen at Searing are three thousand in number.

"The boldness of modern industry, and the colossal range of its operations, exact on the part of the men who direct these, an expansion of views and a rapidity of comprehension and decision similar to what is required in a general; and, not unfrequently, to carry the parallel farther, a degree of courage is demanded on the part of the workmen similar to that which has often ennobled the common business of the soldier. We allude to the occasional bursting of furnaces and other accidents liable to occur both above ground and in the mines, at which times a degree of intrepidity and nobleness of spirit has been repeatedly evinced by common workmen, surpassing, from the superiority of the object in view, all the exploits that were ever performed in the 'imminent deadly breach' of war. Many instances of this kind might be related of the workmen of Belgium.

"A nation, cultivating industrious pursuits with so much sagacity

and intelligence, so completely absorbed, in fact, in active business, might be expected to avail themselves with ardour of the prospects recently opened up by railroads. On the first of May, 1834, a law to the following effect was promulgated by the Belgian government:—

"'Article 1. There shall be established a system, or chain, of railways having Mallines for a centre point, and stretching to the eastward, toward the Prussian frontier by Louvain, Liege, and Verviers—to the north as far as Antwerp—to the west as far as Ostend, by Termond, Ghent, and Bruges–and to the south by Brussels, and towards the frontiers of France through the Hainault.'

"'2. The railways shall be executed at the public charge, and under the direction of the Government.'

"Thus while France is resting in shameful inactivity, in accordance with the ridiculous principle that it is not proper for a Government to interfere with the course of national industry, the little kingdom of Belgium is marching straightforward in the path of prosperity, without embarrassing itself with any prejudicial question of the sort—this line of railroads, crossing to all the cardinal points of the compass, being at this hour in the course of execution. The line from Antwerp to Brussels is completed, and has been traveled for several months. The revenue derived from it has exceeded the highest expectations. With the exception of the line from Brussels to the French frontier, the construction of which must depend on an understanding between the two countries, the whole of the projected Belgian railways will be completed within two years. It is supposed the eastern, western and northern lines, the aggregate length of which is 222 English miles, will be finished at an expense of forty-five millions of francs (1,875,000*l.* sterling.) The proportionate expense per mile, must, of course, vary according to the difficulties, or the facilities of the ground. That portion of the line which extends between Brussels and Antwerp, a distance of thirty-three miles, passes over ground naturally level, and cost 4350*l.* a mile. More inaccessible districts will cost much more than this, as has been said; but it may be questioned whether any part of the Belgian railways will approach near to the expense of the line between Paris and St. Germains; which is estimated at above 24,000*l.* sterling per mile. The abundance of iron in Belgium, will render all public works of this kind comparatively cheap.

"In addition to the 222 miles of railway first projected, nearly 100 miles additional have been subsequently resolved upon, in order to perfect the internal intercourse of the country. When these plans are all completed, the industry of the people will then have every facility in their way that art can afford them; and, as they possess immense internal resources, instead of being a plaything in the hands of every nation that may choose to go to war, Belgium must become a rich and important state. That its inhabitants will also be amongst the happiest on earth, may be pronounced, from the attention which they pay to that inestimable and indispensible possession—education." Ibid.

On the Expansibility of the different kinds of Stone.

Mr. Alex. J. Adie, Civil Engineer, has performed an extensive series of experiments upon different kinds of stone, as well as upon iron and upon brick, porcelain, and other artificial substances. The instrument employed

was a pyrometer of a simple construction, capable of determining quantities not greater than $\frac{1}{300}\frac{1}{000}$ of an inch. The length of the substances generally employed was 23 inches. The general result of these experiments is, that the ordinary building materials of stone expand but very little differently from cast-iron, and that, consequently, the mixture of those materials in edifices is not injurious to their durability. The experiments from which the expansibility of the substances was numerically determined, were made between the limits of ordinary atmospheric temperature and that of 212°; steam being introduced for that purpose between the double casing of the instrument.

The following results were obtained for the fractional expansion of the length, for a change of temperature of 180° Fahr.

Table of the expansion of stone, &c.

	Decimal of length for 180° Fahr.
1. Roman cement,	.0014349
2. Sicilian white marble,	.00110411
3. Carrara marble,	.0006539
4. Sandstone from the Liver Rock of Craigleith Quarry,	.0011743
5. Cast-iron from a rod cut from a bar cast 2 inches square	.00114676
6. Cast-iron from a rod cast half an inch square,	.001102166
7. Slate from Penrhyn Quarry, Wales,	.0010376
8. Peterhead red granite,	.0008968
9. Arbroath pavement,	.0008985
10. Caithness pavement,	.0008947
11. Greenstone from Rutho,	.0008089
12. Aberdeen gray granite,	.00078943
13. Best stock brick,	.0005502
14. Fire brick,	.0004928
15. Stalk of a Dutch tobacco pipe,	.0004573
16. Round rod of Wedgewood ware (11 inches long)	.00045294
17. Black marble from Galway, Ireland,	.00044519

We shall insert Mr. Adie's paper in full as soon as we can find space for it. P. C.

Mechanics' Register.

Cloth of Glass.

M. Dubus Bonnel of Lille has discovered a method of making a cloth of glass, which is perfectly flexible, and may be applied to the hangings of rooms and other purposes. This cloth of glass is extremely beautiful; and, from the manner in which it reflects the light, it surpasses in brilliancy every thing that has ever been attempted with silk, even when combined with gold and silver. Some specimens of this new manufacture have been exhibited in the Passage de l'Opera in Paris; and the Queen of the French was so much pleased with them, that she ordered a golden medal to be sent to the inventor. The following passage is extracted from a French paper: —"When we figure to ourselves an apartment decorated with cloth of glass, and resplendent with lights, we must be convinced that it will equal in brilliancy all that it is possible for the imagination to conceive; it will realise, in a word, the wonders of the enchanted palaces of the *Arabian Tales*. The lights flashing from the polished surface of the glass, to which

any colour or shade may be given, will make the room have the appearance of an apartment of pearls, mother-of-pearl, or diamonds, or composed of garnets, sapphires, topazes, rubies, emeralds, amethysts, &c., or, in short, of all these precious stones united and combined in a thousand ways, and formed into stars, rosettes, bouquets, garlands, festoons, and graceful undulations, varied almost to infinity."—(*L'Echo du Monde Savant*, &c., No. 58, Feb. 15, 1837.) Arch. Mag.

New Locomotive Invention.

Colonel Prince Jasper Bieloselsky-Bielozersky, an officer in the Russian service, has just obtained from the Emperor a ten year's privilege for a new invention, which he denominates a *sledge-road.* The novelty of the principle consists in affixing the wheels to the road instead of to the carriage, the effect of which is said to be a great diminution in the labour of draught. The sledges are proposed to be worked by horses, but there seems no reason why, if the principle should really be found to answer, the superior power of steam should not be made use of. The inventor is sanguine in his expectations of the benefit of his discovery, which, among other recommendations, possesses that of economy. The expense of constructing a sledge-road of the length of a Russian verst would, he calculates, at St. Petersburgh, amount to about 10,350 rubles, which is about £645 per English mile. One of his sledges, which are of a peculiar shape, was manufactured by Clarke, of St. Petersburgh, for 220 rubles. or £9 3*s.* 4*d.* Lon. Mech. Mag.

Locomotive power.

In giving an account of the opening of a portion of the railway, we omitted to mention, as we had intended, that one of the locomotive engines, the Goliah, (George Mann, engineer,) brought down that morning from Kirkhouse, sixty-three wagons of coals in one train—each wagon weighing (with coals) about four tons and a quarter! With this immense load (267 tons) she traveled the distance, twelve miles, in less than forty minutes!—*Carlisle Jour.* Mining Journal.

It would have been well to have mentioned the grade of the road over which thi train passed. G

Expansive Force of Steam.

A circumstance occurred the other day, rather of a singular nature, which strongly illustrates the powerful effects of steam. A strong stone bottle, half filled with water, and tightly corked, was placed by a servant-girl in an oven and forgotten. The water, of course, began to be converted into steam by the heat of the oven, which burst the bottle, and was so expansive as to drive the oven-door, which was of cast-iron, from its hinges against the kitchen wall, with such violence, that it was broken into several pieces. The oven itself, though of considerable weight, was carried from its seat, blew out both the kitchen windows, and tore down the fire-place. Several children were playing in the kitchen, but they fortunately escaped injury.

Mining Jour.

LUNAR OCCULTATIONS FOR PHILADELPHIA, SEPTEMBER 1837.

Angles reckoned to the right or westward round the circle, as seen in an inverting telescope.
☞ For direct vision add 180° ☜

Day.	H'r.	Min.	Phase	Star's name.	Mag.	from Moon's North point.	from Moon's Vertex.
1	23	42	Im.	Venus' Centre,		7	336
2	0	52	Em.			267	252
13	7	44	Im.	Ψ′ Aquarii,	5.6,	163	120
13	8	31	Em.			256	220
17	8	57	Im.	π Arietis,	5,	148	94
17	9	46	Em.			271	218
17	12	18	Im.	ζ² Arietis,	6,	137	88
17	13	30	Em.			291	254

Meteorological Observations for May, 1837.

Moon.	Days.	Therm. Sun rise.	Therm. 2 P.M.	Barometer. Sun rise.	Barometer. 2 P.M.	Wind. Direction.	Wind. Force.	Water fallen in rain.	State of the weather, and Remarks.
				Inches	Inches			Inches.	
	1	43°	46°	29.80	29.80	NW.	Brisk.		Cloudy—clear.
	2	31	58	30.16	30.10	W.	do.		Clear—do.
⊗	3	42	73	29.66	29.66	SW.	Blustering	.11	Cloudy—do.—thunder showers.
	4	40	70	85	90	W.	Moderate.		Clear—do.
	5	50	76	60	60	E.W.	Brisk.		Cloudy—do.
	6	62	81	50	45	SW.	do	.8	Cloudy—do.—shower.
	7	44	62	93	93	NW.	Moderate		Clear—do.
	8	44	63	93	95	E	Calm.		Cloudy—do.
	9	40	69	30.04	30.04	W.	Moderate.		Lightly cloudy—do. do.
	10	54	71	29.70	29.70	W.	do.	.15	Drizzle.—clear.—rain in night.
	11	50	70	90	93	E.W.	do.		Clear—do.
☾	12	50	76	93	30.00	E.	Brisk.		Cloudy—flying clouds.
	13	56	76	30 00	00	SE.S.	Moderate.		Foggy—flying clouds.
	14	60	82	29.90	29.85	SW.	do.		Fog—clear.
	15	58	70	80	74	E.	Brisk.	1.23	Clear—cloudy—rain.
	16	56	69	50	50	E.SE.	Moderate	.88	Rain—cloudy—showers.
	17	58	70	60	64	S.SW.	Brisk.		Cloudy—clear.
	18	50	67	75	75	SE.	do.	.40	Fog—cloudy—thunder shower.
	19	60	73	64	64	S.	Moderate		Cloudy—lightly cloudy.
☹	20	52	67	64	74	W.	Brisk		Cloudy—clear.
	21	53	74	30.00	30.00	W.	Moderate.		Clear—clear.
	22	60	70	00	29.80	SW.	do.	.18	Clear—do.—showers.
	23	48	67	29 90	30.00	W.	do.		Clear—do.
	24	50	54	30 05	10	E	do.		Cloudy—rain.
	25	51	58	29.80	29 70	NE.	do.		Rain—thunder—rain.
	26	51	64	50	60	NE.	do.	2.00	Cloudy—do.
☽	27	50	74	75	70	W.	do.		Clear—do.
	28	54	68	30 00	30.10	NE.W.	do.		Partially cloudy—clear.
	29	48	76	5	3	E W.	do.		Clear—do.
	30	56	82	26.95	23.94	NW.S.	do.		Lightly cloudy.
	31	62	80	95	92	SW.	Brisk.		Fog—Clear.
	Mean	51.26	69.61	2 985	29 3			5.03	

Thermometer.			Barometer.	
Maximum height during the month	82. on 14th 30th.	. .	30.16 on	2d.
Minimum do.	31. on 2d	. .	29.45 on	6th.
Mean do.	60.43 .	. . .	29..83	